Ref. No. A/WG/362/2018

Date: 10.08.2018

To,
The Director (Industry - 2) IA Division,
Ministry of Environment, Forest and Climate Change,
Indira Paryavaran Bhawan,
Jor Bagh Road,
Aliganj, New Delhi- 110003

Subject: Proposed Expansion of Soda Ash & Captive Cogeneration Power Plant at Villages: Mithapur & Surajkaradi, Taluka: Dwarka, District: Devbhumi Dwarka, Gujarat by M/s. Tata Chemicals Ltd. - ***Reg. submission of Additional Details sought***

Ref.: 1. *MoEFCC File no. J-11011/140/2016/-IA.II (I)*

2. Minutes of 39th Meeting of EAC (Industry - 2) held during 25th - 26th July, 2018- Agenda item no. 39.3.13

Respected Sir,

With reference to the aforesaid subject and above cited reference; we would like to appraise your goodself that Final Technical presentation for the above mentioned project was held before EAC (Industry-2) on **26th July, 2018,** in their 39th Meeting.

As per the minutes of 39th EAC (Industry-2) meeting displayed on the website of MoEF&CC, New Delhi; EAC desires few additional information related to the project.

In this regard, we are herewith submitting the point wise reply of the additional details sought by EAC.

We request you to kindly consider our project for further proceeding.

Thanking you and with regards,

M/s. Tata Chemicals Ltd.

B.B. Kathpalia
Vice President (Manufacturing)
(Authorized Signatory)

Encl: As above

TATA CHEMICALS LIMITED
Mithapur 361 345 District Devbhoomi Dwarka Gujarat
Tel + 91 (02892) 665991 / 2 / 3 / 4 Fax + 91 (02892) 223361 www.tatachemicals.com
Registered Office Bombay House 24 Homi Mody Street Fort Mumbai 400 001
CIN : L24239MH1939PLC002893

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Point wise Reply of

Additional Details Sought

FOR

Proposed Expansion of Soda Ash

&

Captive Cogeneration Power Plant

At

Villages: Mithapur and Surajkaradi,

Taluka Dwarka, District Devbhumi Dwarka, Gujarat

APPLICANT

M/s.Tata Chemicals Ltd.

Mithapur, and Surajkaradi, Taluka - Dwarka,

District - Devbhumi Dwarka,

Gujarat - 361 345

Minutes of the 39th Expert Appraisal Committee (Industry-2) Meeting held during 25-27 July, 2018 at Indira Paryavaran Bhawan, Jor Bagh Road, Ministry of Environment, Forest and Climate Change, New Delhi - 3

Day one - 25th July, 2018

39.1 Opening Remarks by the Chairman

39.2 Confirmation of minutes of the 38th meeting of the EAC (Industry-2) held on 25-27 June, 2018 at Indira Paryavaran Bhawan, New Delhi.

The EAC, having taken note that no comments were offered on minutes of its 38th meeting held on 25-27 June, 2018 at New Delhi, confirmed the same.

39.3 Environmental Clearance

Agenda No.39.3.1

Expansion of molasses based distillery from 35 KLPD to 65 KLPD by M/s Brima Sagar Maharashtra Distilleries Ltd at Shreepur, Taluka Malshiras, District Solapur (Maharashtra)

[IA/MH/IND2/67191/2017, J-11011/192/2017-IA-II (I)]

39.3.1.1 The project proponent and the accredited Consultant M/s Dr. Subbarao's Environment Center made a detailed presentation on the salient features of the project and informed that:

(i) The proposal is for environmental clearance to the project Expansion of existing molasses based distillery from 35 KLPD to 65 KLPD by M/s Brima Sagar Maharashtra Distilleries Ltd at Shreepur, Taluk Malshiras, District Solapur (Maharashtra).

(ii) The project proposal was considered by the Expert Appraisal Committee (Industry-2) in its 13th meeting held during 19th November, 2013 and recommended Terms of References (ToR) for the Project. The ToR has been issued by Ministry vide letter No.J-11011/249/2013-IA.II(I) dated 31st January, 2014.

(iii) The project proponent applied for amendments in ToRs which were approved, vide F.No.J-11011/249/2013-IA.II(I) dated 8th May, 2015.

(iv) The project proponent submitted the EIA report for Environmental Clearance which was considered by the Expert Appraisal Committee (Industry-2) in its 24th meeting held during 14th to 16th June, 2017. The EAC did not approve the EIA Report as it was not submitted within the stipulated period of 3 years after the grant of the ToRs. The Committee recommended the Standard ToRs for preparation of EIA Report, and the additional ToRs were given as:

- Fresh baseline Data to be Submitted
- Public Hearing is exempted under the provision as per Para 7(ii) of the EIA Notification 2006

(v) All molasses based distillery projects are listed at S.N. 5(g) of Schedule of Environment Impact Assessment (EIA) Notification under category 'A' and are appraised at Central Level by Expert Appraisal Committee (EAC).

39.3.10.3 *The EAC, after deliberations and especially in view of the unit proposed in non-industrial area, desired for concurrence of the State Pollution Control Board to allow APIs manufacturing therein.*

The proposal was, therefore, not taken forward for the needful.

Agenda 39.3.13

Expansion of Soda Ash and Captive Cogeneration Power Plant at village Mithapur & Surajkaradi, Taluka Dwarka, District Devbhumi (Gujarat) by M/s TATA Chemicals Ltd.

[IA/GJ/IND2/53444/201, J-11011/140/2016-IA II (I)]

39.3.13.1 The Project Proponent and the accredited Consultant M/s. J.M. Enviro Net Pvt Ltd made a detailed presentation on the salient features of the project and informed that:

(i) The proposal is for environmental clearance to the project for proposed expansion of Soda Ash & Captive Cogeneration Power Plant at Villages Mithapur & Surajkaradi, Taluka Dwarka, District: Devbhumi Dwarka, Gujarat by M/s. Tata Chemicals Ltd.

(ii) The project proposal was considered by the Expert Appraisal Committee (Industry-2) in its 9th meeting held during 27th-28th June, 2016 and recommended Terms of References (ToRs) for the project. The ToR has been issued by Ministry vide Letter No. J-11011/140/2016-IA.II.(I) dated 2nd August, 2016.

(iii) All activities are listed at S.No. 4(e) {Soda Ash Industry} and 1(d) {Thermal Power Plant} of Schedule of Environment Impact Assessment (EIA) Notification under category 'A' and are appraised at Central Level by Expert Appraisal Committee (EAC).

(iv) Ministry had issued EC earlier vide letter no. J-13011/20/2006.IA-II(T) dated 22nd May, 2006; amended on 30th May, 2007 for expansion of Captive Co-generation Power Plant in favour of M/. Tata Chemicals Ltd.

(v) Existing land area is 231 Ha (2310000 m^2). No additional land will be required for proposed expansion.

(vi) Greenbelt will be developed in an area of 33 % i.e., 131 Ha (1310000 m2) out of total area of the project.

(vii) The estimated project cost is Rs.1042.07 crores including existing investment of Rs.2977.30 crores. Total capital cost earmarked towards environmental pollution control measures is Rs.80.79 crores and the Recurring cost (operation & maintenance) will be about Rs.16.29 crores per annum. Total Employment generation will be 4551 persons as direct & 10,262 persons indirect after expansion.

(ix) There are Marine National Park and Marine Sanctuary (2.19 km in East direction), within 10 km distance from the project site. Shamlasar River is flowing at a distance of 9.7 km in SE direction. Bhimgaja Rainwater Lake is at a distance of 9.7 km in SE direction. Gopi Talav is at a distance of 9.5 km in ESE direction. Arabian Sea is at a distance of 2.44 km. Gulf of Kutch is at a distance of 2.19 km.

(x) Ambient air quality monitoring was carried out at 9 locations during (Post Monsoon Season, 2016) October to December, 2016 and the baseline data indicates the ranges of concentrations PM10 (36.52 to 74.21 $\mu g/m^3$), PM2.5 (8.71 to 27.13 $\mu g/m^3$), SO_2 (4.63 to 12.40 $\mu g/m^3$) and NO_2 (6.55 to 15.21 $\mu g/m^3$). AAQ modeling study for point source emissions indicates that the maximum incremental GLC's after the proposed expansion project would be 1.56 $\mu g/m^3$, 4.19 $\mu g/m^3$ and 1.39 $\mu g/m^3$ with respect to PM_{10}, SO_X and NO_X. The resultant concentrations are within the National Ambient Air Quality Standards (NAAQS).

(xi) Total Sea water requirement is 30,872 m3/day for proposed expansion which will be met from existing sea water intake facility. There is no additional fresh water requirement for proposed expansion.

(xii) Effluent (Treated waste water) of 2,40,000 m3/day quantity will be treated through existing facilities.

(xiii) Power requirement after expansion will be 92.60 MW including existing 62.97 MW and will be met from Captive Co-generation Power Plant (Total capacity after expansion 125 MW). Existing unit has 09 DG sets of 8318 Kvacapacity which are used as standby during power failure. There is no proposed DG sets.

(xiv) Existing unit has 757 TPH (Steam generation capacity) Coal/Petcoke (Fuel) fired boilers. Additionally Coal/ Petcoke fired boiler of 300 TPH capacity will be installed. ESP with a stack of height 130 m will be installed to control the particulate emissions within the statutory norms of 30 mg/Nm3 for the proposed boiler.

(xvi) Details of Solid waste/ Hazardous waste generation and its management is given in EIA Report (Chapter-10, Section 10.5).

(xvii) Public Hearing for the proposed project has been conducted by the State Pollution Control Board on 17th Feb., 2018. The main issues raised during the public hearing are related to Local Employment, Environment, Health and Education.

(xviii) Certified compliance report of existing EC for Captive Co-generation Power Plant is obtained from Regional office of MoEFCC vide letter no. 5-13/2000(ENV)/138 dated 23rd May, 2018.

(xix) No litigation is pending against the proposal.

(xx) The details of products are as under:

S. No.	Product Details	Unit	Existing Capacity	Proposed Capacity	Total Capacity
1.	Soda Ash	TPA	10,91,000	2,25,000	13,16,000
2.	Power	MW	85	40	125
3.	Steam	TPH	757	300	1057

39.3.13.2 During deliberations, the EAC noted the following: -

The proposal is for environmental clearance to the project for expansion of Soda Ash (1091000 to 1316000 TPA) & Captive Cogeneration Power Plant (85 MW to 125 MW) by M/s Tata Chemicals Ltd in a total area of 231 ha at Villages Mithapur & Surajkaradi, Taluka Dwarka, District Devbhumi Dwarka (Gujarat).

The project/activities are covered under category A of item 4(e) 'Soda ash industry' of the Schedule to the Environment Impact Assessment Notification, 2006, and requires appraisal at central level by the sectoral EAC in the Ministry.

The ToR for the project was granted on 2nd August, 2016. Public hearing was conducted by the SPCB on 17th February, 2018.

Total existing water requirement is 30,872 m3/day. No additional fresh water will be required for proposed expansion.

Total effluent generated from different industrial operations is estimated to be 53.8m3/day. Generated effluent will be treated through Effluent Treatment Plant followed by MEE. Domestic effluent of 3.8 m3/day will be disposed off through Septic tank/ Soak pit system. There will be no discharge of treated/untreated waste water from the unit, and thus conforming to Zero Liquid Discharge.

Earlier, Ministry had issued environmental clearance vide letter 22nd May, 2006 for expansion of Captive Co-generation Power Plant; amended on 30th May, 2007 to the existing Captive Co-generation Power Plant in favour of M/s. Tata Chemicals Ltd.

The monitoring report on compliance status of above EC conditions issued by the Regional office Bhopal to the project proponent vide letter dated 23rd May, 2018 and was found satisfactory.

39.3.10.3 *The EAC, after deliberations, asked for additional information/inputs and clarifications in respect of the following:-*

- *Clarification on requirement of recommendations/clearance from wildlife angle for the soda ash and captive power plant,*
- *Status of forest clearance for diversion of 11.268 ha of mangrove forests, earmarked for laying of discharge pipeline,*

- *Impact of the project on the marine environment including marine national park/sanctuary/mangrove,*
- *ESZ map of Marine National Park and Marine Sanctuary,*
- *Details on water requirement and its source.*
- *Changes in the existing water intake pipeline and also the effluent discharge along with the water quality parameters.*

The proposal was, therefore, deferred for the needful on the above lines.

39.4 Amendment in Terms of Reference

Agenda No.39.4.1

Capacity Expansion from 13.7 to 18 MMTPA with 100% BS-VI Auto Fuel Production at Vadodara (Gujarat) by M/s Indian Oil Corporation Limited Gujarat Refinery

[IA/GJ/IND2/73416/2018, J-11011/93/2018-IA-II(I)]

39.4.1.1 The proposal is for amendment in the standard terms of reference issued by the Ministry vide letter dated 14th April, 2018 to the project for capacity expansion of Gujarat Refinery from 13.7 to 18 MMTPA with 100% BS-VI Auto Fuel Production by M/s Indian Oil Corporation Limited at Vadodara (Gujarat).

39.4.1.2 The project proponent has requested for amendment in the ToR with the details are as under:-

S. No.	Para of ToR issued by MoEF&CC	Details as per the ToR	To be revised / read as	Justification / reasons
1.	Pg 9, Point No. ix	Submission of draft EIA/RA report to SPCB for conduct of Public Hearing	Waiver of Public Hearing	PH was conducted at Gujarat refinery on 5th November, 2016 for BS-IV/VI project for which Environmental Clearance has already been granted. The new projects envisaged in the same BS-IV/VI project site.

39.4.1.3 *The EAC, after deliberations and especially in view of the last public hearing conducted by the State Pollution Control Board on 5th January, 2016 for another project namely BS-IV and BS-VI Project at the same refinery in District Vadodara (Gujarat), not more than 3 years old, agreed for exemption from fresh public hearing and amending the ToR dated 14th April, 2018 accordingly.*

Agenda No.39.4.2

Point-wise Reply of Additional Details Sought

Reference: *Minutes of 39thEAC (Industry - 2) Meeting held on 25th - 27th July, 2018 (Agenda item no. 39.3.13)*

MoM Para: 39.3.13.2

"Total effluent generated from different industrial operations is estimated to be 53.8m3/day. Generated effluent will be treated through Effluent Treatment Plant followed by MEE. Domestic effluent of 3.8 m3/day will be disposed off through Septic tank/ Soak pit system. There will be no discharge of treated/untreated waste water from the unit, and thus conforming to Zero Liquid Discharge".

TCL Clarification: The above details are not given by TCL for expansion proposal. Quantity of Treated waste water will be within existing consent limit of 240,000 m^3/day.

Point-wise Reply of Additional Detail Sought

Point No.	Additional Detail Sought	Reply
i.	Clarification on requirement of recommendations/ clearance from wildlife angle for the soda ash and captive power plant.	▪ Following National Park & Sanctuary falls within 10 km radius of the plant site: o Marine National Park (~2.9 km in NW direction) o Marine Sanctuary (~ 2.4 km in East direction) ▪ Eco-sensitive Zone of both the above mentioned protected areas have been notified *vide* MoEFCC Notification No. SO 2561 (E) dated 22nd Aug., 2013. ▪ The distance of the plant site from the notified Eco- sensitive zone is as given below: o Marine National Park Eco-Sensitive Zone (~2.7 km in NW direction) o Marine Sanctuary Eco-Sensitive Zone (~1.4 km in East direction) Since, the project site does not fall within ESZ of Marine National Park and Marine Sanctuary; therefore, wildlife clearance/recommendation is not required. However, TCL has obtained Wildlife clearance vide letter No. WLP/32/B/1813-18/2017-18 dated 01.06.2017 for discharge of treated waste water into Sea (Gulf of Kutchh).
ii.	Status of forest clearance for diversion of 11.268 ha of mangrove forests, earmarked for laying	Tata Chemicals Ltd. company has applied for clearance under Forest Conservation Act, 1980 (Proposal No.: FP/GJ/IND/33165/2018). The proposal has been recommended by the Conservator of Forests / Chief Conservator of Forests, Marine National Park, Jamnagar and forwarded to Nodal Officer, Gujarat for further processing.

Point No.	Additional Detail Sought	Reply
	of discharge pipeline.	System generated Email alert reg. the status of the proposal is enclosed as ***Annexure - 1***.
iii.	Impact of the project on the marine environment including marine national park/ sanctuary/ mangrove.	The impact of the proposed expansion on Marine National Park, Marine Sanctuary and Mangroves has been assessed by following methods: ▪ *Air Quality Impact Prediction through Mathematical Modelling using AERMOD.* Details of the Air Pollution Impact Prediction due to proposed expansion (cumulative for Soda Ash, Captive Cogeneration Power Plant & Cement Plant) on Marine National Park, Marine Sanctuary and Mangroves is given in ***Annexure - 2.*** ▪ *Study on Impact of Discharge of Treated Waste Water.* Following studies have been conducted to assess the impact of proposed expansion project on marine life and sea water quality. ✓ Marine Impact Assessment Study conducted by Central Salt and Marine Chemicals Research Institute, Bhavnagar run by Council of Scientific and Industrial Research (CSIR) in October, 2017. Marine Impact Assessment Study Report is enclosed as ***Annexure - 3.*** ✓ Water Quality Modeling for Treated Waste Water Discharged into Sea (Mithapur Bay) conducted by M/s. Kadam Environmental Consultants, Vadodara. Water Quality Modelling Report is enclosed as ***Annexure - 4.*** ▪ *Study on Impact on Biodiversity* Impact on Biodiversity has been studied and mitigation measures has also been proposed. The same has been given in Wildlife Conservation Plan; which is duly certified by CWW, Gujarat *vide* letter no. WLP/32/C/144-45/2018-19 dated 19th June, 2018. Details are given in ***Annexure - 5.***
iv.	ESZ map of Marine National Park and Marine Sanctuary.	▪ Following National Park & Sanctuary falls within 10 km radius of the plant site: o Marine National Park(~2.9 km in NW direction) o Marine Sanctuary (~ 2.4 km in East direction) ▪ Eco-sensitive Zone of both the above mentioned protected areas have been notified *vide* MoEFCC Notification No. SO 2561 (E) dated 22nd Aug., 2013.

Point No.	Additional Detail Sought	Reply
		▪ The distance of the plant site from the notified Eco- sensitive zone is as given below: o Marine National Park Eco-Sensitive Zone (~2.7 km in NW direction) o Marine Sanctuary Eco-Sensitive Zone (~1.4 km in East direction) A map showing location of Plant site and Marine National Park & Marine Sanctuary within 10 km radius of the plant site along with their Eco-Sensitive Zones, duly Authenticated by Chief Wildlife Warden, *vide* Letter No.WLP/32/C/144-45/2018-19 dated 19thJune, 2018 has been enclosed as ***Annexure - 6.***
v.	Details on water requirement and its source.	No additional fresh water will be required for the proposed expansion project. Details on water requirement and its source are given as ***Annexure - 7.***
vi.	Changes in the existing water intake pipeline and also the effluent discharge along with the water quality parameters.	No change is proposed in existing sea water intake system. Map showing existing intake system is enclosed as ***Annexure - 8(a).*** Treated Effluent is discharged in Gulf of Kutch through the existing facility as per the prescribed norms given in GPCB Consent (capacity - 2,40,000 m^3/day). However, TCL proposal for pipeline and diffuser system has already been obtained CRZ Clearance vide Letter No. 11-34/2016-IA-III dated 10th July, 2017 *{copy enclosed as **Annexure - 8(b)**} and* Wildlife Clearance vide letter No. WLP/32/B/1813-18/2017-18 dated 01st June, 2017 *{copy enclosed as **Annexure - 8(c)**}*. Details regarding water quality parameters of the effluent discharged is given in ***Annexure-8(d).***

-----@---@---@-----

---------- Forwarded message ----------
From: <monitoring-fc@nic.in>
Date: 4 August 2018 at 12:00
Subject: Email Alert From System Administrator of Online Submission and Monitoring of Forests Clearances Proposal(OSMFCP) portal
To: pctank@tatachemicals.com
Cc: monitoring-fc@nic.in

INTIMATION
Regarding FC Proposals Submitted by the Proponent / User Agency

A proposal (Form-A, Part-I and Part-II) seeking prior approval of Central Government under the Forest (Conservation) Act 1980, as per the details given below, has been recommended by the Conservator of Forests / Chief Conservator of Forests, Marine National Park,Jamnagar and forwarded to Nodal Officer, Gujarat for further processing.

1. Proposal No.	:	FP/GJ/IND/33165/2018
2. Proposal Name	:	Proposal for treated waste water pipeline by Tata Chemicals Limited, Gujarat
3. Category of the Proposal	:	Industry
4. Date of Submission	:	17/04/2018

5. Name of the Applicant with Contact Details

Name	:	Paresh
Mobile No.	:	9227544806
State	:	Gujarat
District	:	Ahmedabad
Pincode	:	380014

6. Area Applied (ha.)	:	11.268

This is for your kind information.

(System Administrator)

*** This is a system generated email, please do not reply. ***

Annexure - 2

Impact of the Proposed Expansion on Marine National Park and Marine Sanctuary and its ESZ

1. *Air Quality Impact Prediction*

Air Pollution Impact Prediction due to proposed expansion (cumulative for Soda Ash, Captive Cogeneration Power Plant & Cement Plant) on the nearby sites has been assessed through Mathematical Modeling done using AERMOD. The model simulations deal with major pollutant PM, SO_2 & NO_x.

Cumulative peak incremental concentration for different scenarios is given in table below:

S. No.	Location	Monitored Maximum concentrations (Nearest Location)			Predicted incremental Maximum concentrations			Resultant Maximum concentrations			NAAQS (dated 2009)		
		PM	SO_2	NO_x	PM	SO_2	NO_x	PM	SO_2	NO_x	PM	SO_2	NO_2
1.	Marine National Park	69.71	9.81	11.36	0.06	0.29	0.10	69.47	10.1	11.46	100	80	80
2.	Marine Sanctuary	59.32	8.01	10.17	0.18	0.73	0.31	59.5	8.77	10.81			
3.	ESZ - Marine National Park	69.71	9.81	11.36	0.07	0.35	0.12	69.48	10.17	11.48			
4.	ESZ - Marine Sanctuary	59.32	8.01	10.17	0.21	0.95	0.31	59.56	8.99	10.78			

Air quality modeling result shows that the resultant concentrations of pollutants at all locations will be within the prescribed standards. Also, the existing air pollution control equipments are proposed to upgrade from emission levels of 150 mg/Nm^3 to below 30mg/Nm^3 in cement plant.

Therefore, the impact identified due to the proposed expansion is of negligible significance.

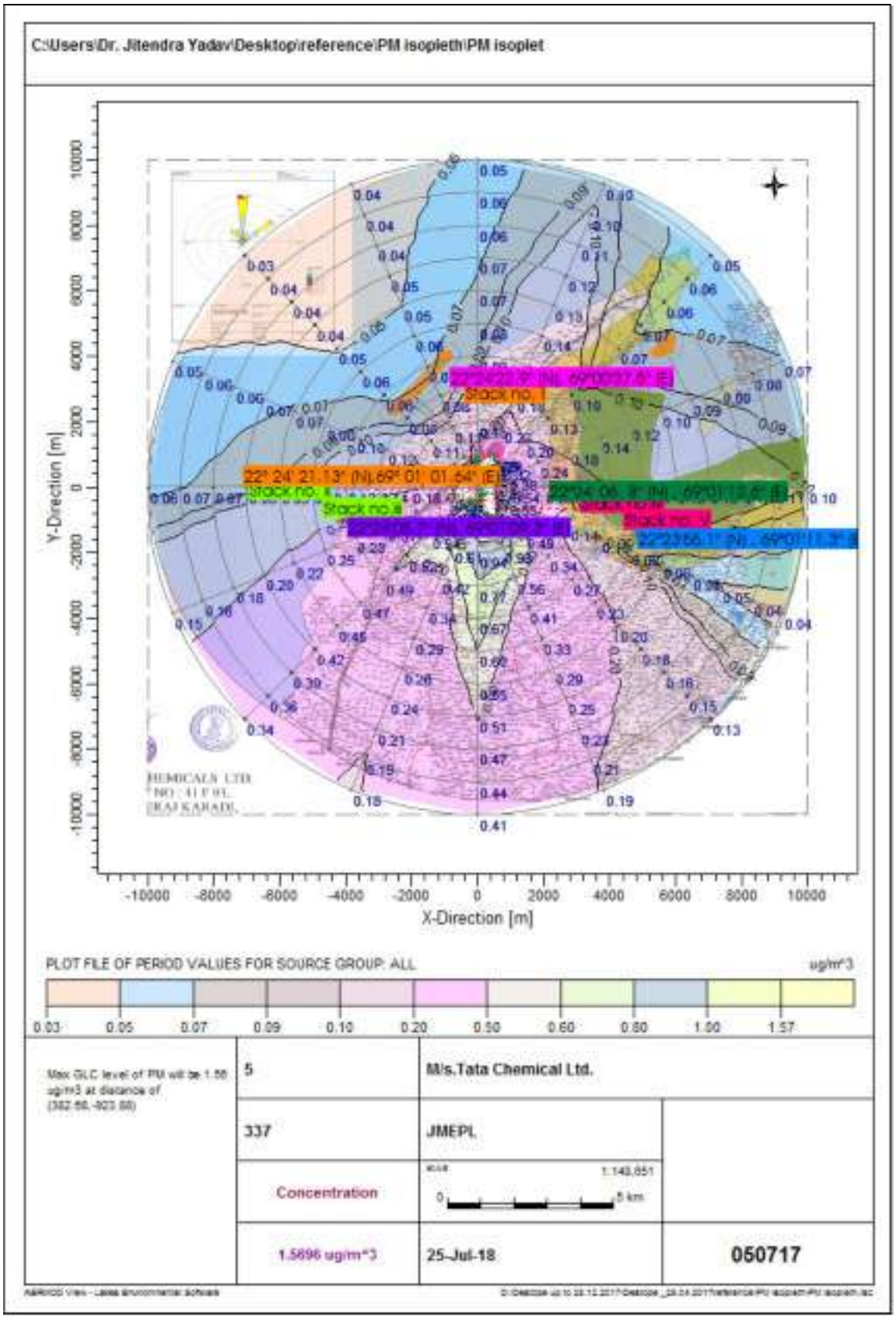

Figure 1- Isopleth showing max. GLC of PM

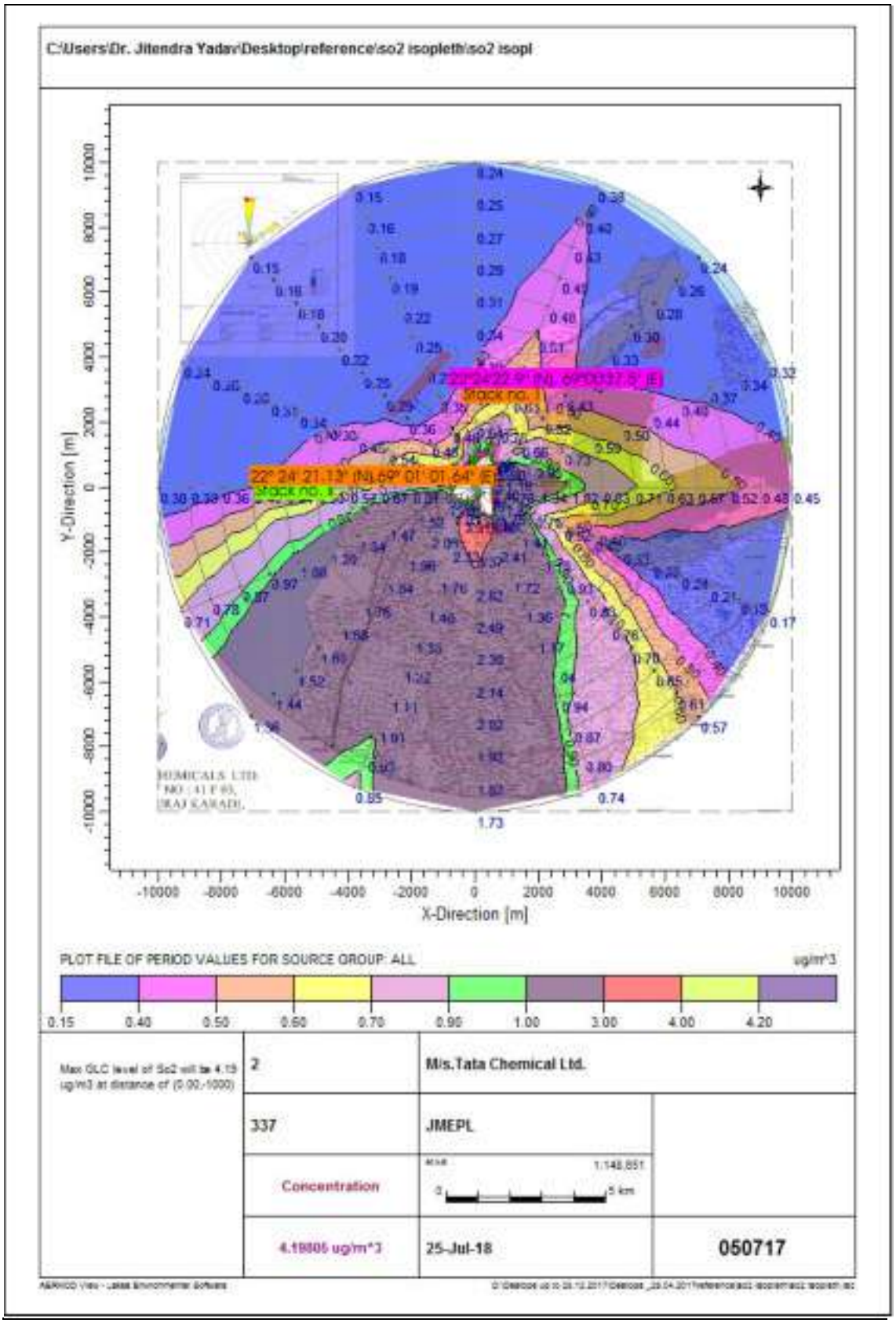

Figure 2 - Isopleth showing max. GLC of SO_2

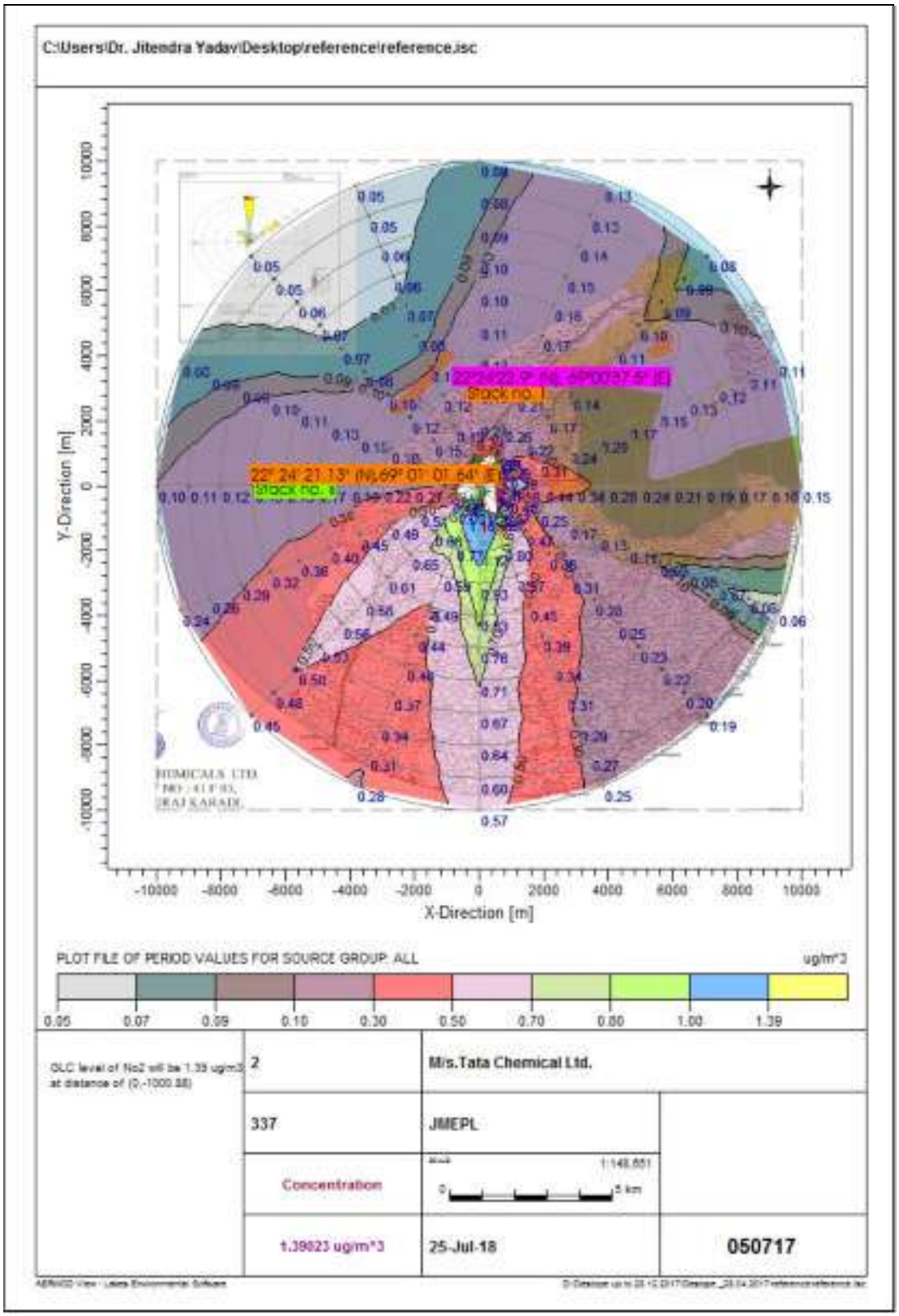

Figure 3 - Isopleth showing max. GLC of NO_2

सीएसआईआर–सीएसएमसीआई
CSIR-CSMCRI

Final Report

Assessment of impact on marine ecology off Mithapur due to release of treated effluents from Tata Chemicals Limited

Prepared by

CSIR-Central Salt and Marine Chemicals Research Institute

Gijubhai Badheka Marg, Bhavnagar – 364 002

June 2018

PROJECT PERSONNEL

CSIR-CSMCRI, Bhavnagar

Project Team

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Dr. R.B. Thorat, Principal Scientist

Mr. Anil Kumar M, Scientist

Project Staff

Mr. Narshibhai R Baraiya, Technician

Ms. Manali Rathod, Project Staff

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Mr. Pratik D Sengani, Project Staff

Mr. Amit Chanchpara, Project Staff

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1.0 About Tata Chemicals Limited

A part of the over US$ 100 billion Tata Group, Tata Chemicals Limited (TCL), is a global company with interests in businesses that focus on LIFE —Living, Industrial and Farm Essentials. The story of the company is about harnessing the fruits of science for goals that go beyond business.

Through its Living Essentials portfolio the company has positively impacted the lives of millions of Indians. TCL is the pioneer and market leader in India's branded iodised salt segment. Extending its portfolio from salt to other food essentials, the Company unveiled India's first national brand of pulses, followed by a range of spices housed under the Tata Sampann brand. TCL has been rated as one of the top 10 in Business and Consumer brands across all industry and consumer brand categories in India by Superbrands.

The company's Industry Essentials product range provides key ingredients to some of the world's largest manufacturers of glass, detergents and other industrial products. TCL currently is the world's second largest producer of soda ash with manufacturing facilities in Asia, Europe, Africa and North America. With its Farming Essentials portfolio, the company has carved a niche in India as an agri-inputs provider. It is a key player in specialty and complex fertilisers and, through its subsidiary Rallis, has a strong position in the crop protection business. The Tata Chemicals Innovation Centre is home to world class R&D capabilities in the emerging areas of nanotechnology and biotechnology. In line with its mission, 'serving society through science', the company is applying its expertise in sciences, to develop high-tech and sustainable products.

2.0 Proposed expansion activities

TCL has proposed expansion of Soda Ash and Cement production capacities and Captive Cogeneration Power Plant within the existing Chemical Complex at Mithapur, District- Devbhumi Dwarka (Gujarat). As per EIA Notification dated 14.09.2006 and subsequent amendments, the proposed expansion of TCL falls in Category 'A', Project Activity S. No. – 4(e) [Soda Ash Industry], 3(b) [Cement Plant] and 1(d) [Thermal Power Plant].

Ministry of Environment, Forest and Climate Change (MOEF&CC) has issued following Terms of References (ToRs) for the above proposals:

1. Expansion of Soda Ash and Captive Power Plant vide ToR letter No. J-11011/140/2016-IA.II(I) dated 02 August 2016 by EAC Industry-I Committee
2. Expansion of Soda Ash and Captive Power Plant vide ToR letter No. J-11011/66/1999-IA.II(I) dated 10January 2017EAC Industry-II Committee

As per Terms of Reference (ToR) No.B Additional ToR (iv), impact on marine life is to be assessed and included in the Environment Impact Assessment (EIA) study.

Central Salt and Marine Research Institute (CSIR – CSMRI) conducted the study to assess the impacts on marine ecology off Mithapur due to the release of treated waste water into the Sea (Gulf of Kutchh) by TCL.

3.0 Project information

Mithapur complex of TCL is located close to the Arabian Sea as well as the Gulf of Kutch on the western coast of Gujarat (Figure 3.1). The industrial township of Mithapur is situated 20 km North of Dwarka and 9 km South of the port of Okha on State Highway 25-A. Western Railway's broad gauge line from Mumbai to Okha, passes through Mithapur. The proposed expansion in the soda ash, cement and cogeneration power plant will be done within the existing plant premises. The salient features of the project are given in Table 3.1:

Table 3.1: Salient features of the project

A	**Production Details**				
S.No.	**Name of Activity**	**Unit**	**Existing Capacity**	**Proposed (addition) capacity**	**Total capacity after proposed expansion**
1	Soda Ash	MT/Year	10,91,000	225,000	1,136,000
2	Sodium Bicarbonate	MT/Year	1,50,000	Nil	1,50,000
3	Vacuum and Pure Salt	MT/Year	11,00,000	Nil	11,00,000
4	Caustic Soda	MT /Year	36,000	Nil	36,000
5	Liquid Chlorine	MT /Year	18,000	Nil	18,000
6	33% Hydrochloric Acid	MT /Year	64,800	Nil	64,800
7	Bromine	MT /Year	2,400	Nil	2,400
8	Gypsum	MT /Year	1,34,892	Nil	1,34,892
9	Clinker	MT /Year	8,25,000	Nil	8,25,000
10	Cement (OPC/PPC)	MT /Year	7,87,000	113,000	900,000
11	Desalination (RO Plant)	M^3/Year	2,160,498	Nil	2,160,498
12	Power	MW	85	40	125
13	Steam	T/hour	757	300	1057
B	**Location Detail**				
a)	Place	Mithapur			
b)	Taluka	Dwarka			
c)	District	Devbhumi Dwarka			
d)	State	Gujarat			
e)	Latitude	Within Existing Chemical Complex East: 22° 24' 55.9"N; 69° 01' 19.1"E West: 22° 24' 11.8"N; 69° 00' 16.3"E North: 22° 25' 04.3"N; 69° 01' 03.0"E South: 22° 23' 41.8"N; 69° 01' 17.8"E			
f)	Longitude				
g)	Proposed project side	Within Existing Chemical Complex			

4.0 Project description with process details

4.1 Soda ash plant

Soda ash, at TCL is manufactured by the conventional Ammonia Soda (Solvay) process. Salt, sea water, lime stone, coke and ammonia are the main raw materials. The overall chemical reaction is as follows:

$CaCO_3 + 2NaCl = Na_2CO_3 + CaCl_2$

The major steps involved in the manufacturing process of soda ash are as follows:

1. Brine preparation and purification
2. Limestone calcination
3. Lime hydration- milk of lime production
4. Absorption of ammonia
5. Gas compression
6. Carbonation of ammoniated brine
7. Filtration
8. Calcination
9. Recovery of ammonia
10. Storage and packing

Process flow diagram for Soda ash plant is given in Figure 4.1.

4.2 Cement plant

The raw materials for manufacture of cement are limestone, blue dust, clay, sandstone, laterite, dry soda ash effluent solids, gypsum, fly ash and undersize limestone from soda ash plant. The undersize limestone separated in soda ash plant is reduced to desired size in the crusher and stacked in a storage area. The blended limestone is reclaimed and conveyed to the raw mill storage bin area. Other raw materials like blue dust and clay are trucked into the plant and conveyed to individual storage bins in the raw mill area through belt conveyor.

Resource optimization/recycling and reuse

a) Utilization of undersize limestone generated from soda ash manufacturing process

Undersize limestone generated during the sizing process is used in the Cement Plant as raw material. The undersize limestone is utilized by crushing and grinding to feed rotating kiln in cement plant. The utilization of undersize limestone helps in solid waste management and fresh limestone resource conservation.

b) Utilization of effluent solids in cement manufacturing

Effluent solids are recovered from soda ash ammonia still effluent and utilized in cement manufacturing. Thus the cement plant, in a way, serves the purpose of waste utilization by consuming solid wastes generated in the chemical complex. Effluent solid filtration plant is first of its kind in the world. Apart from the effluent filtration, this process of effluent treatment gives benefit of conserving natural resources thereby reducing fresh limestone consumption. The reduction in fresh limestone consumption reduces the carbon emission due to decrease in transportation volume.

c) Power plant fly ash utilization

Fly ash generated from boilers is used in the cement plant, supplied to brick manufacturers, land filling, bund making and greenbelt development. The mycorrhiza technology developed by The Energy and Resources Institute (TERI), New Delhi has been adopted for green belt development in land filling areas of fly ash.

4.3 Power plant

The power plant operates on the "Total Energy Concept"– raising steam at high pressure (110 kg/cm^2), generating power out of this at Topping Turbines and supplying the exhaust steam at (30 kg/cm^2) to the various process units (Steam tube dryers and compressors in Soda Ash plant) as well as to Low Pressure Turbines. These turbines generate additional power and low pressure steam, which are used at ammonia stills in the Soda Ash plant (at 1.5 kg/cm^2) and the Vacuum Evaporated Salt plant (at 3.5 and 1.5 kg/cm^2). The process flow diagram of captive co-generation power plant is illustrated in Figure 4.2.

5.0 Fresh water and sea water requirements

TCL has eliminated dependence on ground water since April 2007 by adopting various in-house water conservation measures as well as management of the rain-fed lakes and innovative seawater desalination technologies. More than 98% of all water needs at the complex are met by seawater. Water requirements and their sources are listed in Table 5.1. The Company has implemented water management concepts of Reduce, Recycle, Reuse, Replace and Generate (Water). This is achieved by the following means:

- ✓ Substitution of fresh water by seawater in cooling towers
- ✓ Substitution of process water by treated seawater for brine preparation
- ✓ Water conservation initiatives within the complex
- ✓ Internal generation of water from steam jet refrigeration and waste heat desalination, RO plant
- ✓ Recycle/reuse of treated domestic sewage within the Company Township for toilet flushing and horticulture.

Table 5.1: Water requirements and sources

Basic requirements for the project	Existing	Additional for proposed expansion	Total after proposed expansion
Fresh water (m^3/day) (Annualised average)	7,100	Nil	7,100
	Source: Rain water lake		
Sea water (m^3/day) (Annualised average)	2,46,721	31,095	2,77,816
	Source: Arabian Sea		

6.0 Effluent management system

6.1 Disposal of treated industrial waste water

TCL Mithapur plant utilizes sea water for various applications inside the plant including for cooling applications. Concentrated brine is the raw material for production of various chemicals in the plant. The plant generates treated waste water from its various processes which is discharged into the Gulf of Kutch, through an open channel after solids separation and dilution with spent seawater from plant cooling water system.

TCL's chemical complex has implemented integrated waste management system for reuse and recycling of waste streams and utilizes sea water for its cooling requirements. Effluent streams from Chlor Caustic plant are recycled in the manufacturing process of soda ash plant. Treated waste water generated from soda ash unit, spent cooling sea water and other streams from chemical complex are discharged into the sea through a single outlet as per prescribed norms (Table 6.1). Scheme of treated waste water disposal is given in Figure 6.1.

TCL has implemented effluent management system which ensures compliance of treated waste water quality within limit for the parameters Total Suspended Solids (TSS), pH, Ammonical Nitrogen, Temperature, Color, Oil & Grease and Bioassay Test as per the Consent Order of the Gujarat Pollution Control Board (GPCB). Following process is implemented to achieve concentration of TSS in the final treated waste water within the GPCB norms:

a. Effluent solid filtration: Effluent generated in soda ash ammonia still process is partially filtered in effluent solid filtration plant and the filtered solids are utilized in cement manufacturing. Company has developed a pioneering process to use the solids recovered from the soda ash effluent in cement making.

b. Settling of suspended solids: Suspended solids are further settled in sedimentation basins.

c. Dilution with spent sea water: Clear effluents after the above processes (a and b) are mixed with spent cooling sea water and final treated waste water is discharged into the sea.

6.2 Monitoring under ICZM Project

(Source: GPCB Report, June' 2013- Monitoring of Physico-chemicals parameters, ICZM Project)

In Gujarat, Gulf of Kutchh has been identified as a project location for implementation of the Integrated Coastal Zone Management (ICZM) Plan. The ICZM Project consists of majorly four components namely,
1) Coastal Resource Conservation and Management,
2) Coastal Environmental Monitoring and Conservation,
3) Socioeconomic Development of Communities,
4) Integration of Geospatial Information in Coastal Zone Management.

STUDY AREA: The Gulf of Kutchh, lies between N 20° 15' and 23° 35' latitude and E 68° 15' and 70° 22' longitude encompassing about 1000 km long shoreline covering an area of about 7350 km^2. The

Gulf of Kutch has an area of negative water balance, where evaporation is more than the total rainfall and river runoff leading to relatively high salinity throughout the year. The sediment movement in the Gulf is regulated by prograding sediment of the river Indus, which opens about 100 km towards the north of the Gulf of Kutch discharging an annual load of about 435 million tonnes of Suspended Solids. Some of the suspended sediments are transported in a south easterly direction in to the Gulf, where the sediments are in transit under the action of high velocity tidal currents.

Sea Water Monitoring for Physico-Chemical Parameters by GPCB: As a part of Coastal Environmental Monitoring under the ICZM Project, quality of treated waste water entering the Gulf and near shore sea water quality have been monitored by GPCB in at following locations:

S.No.	Sampling Location	Monitoring Reports
1	Final Outlet of Tata Chemicals, Mithapur	Annexure-3
2	Sea water sample of Tata Chemicals Ltd., Arambhada	Annexure-2

Conclusion: Report on Monitoring of Physico-chemicals parameters published by GPCB in June' 2013 concludes as below:

1. Treated waste water quality found within prescribed norms
2. Sea Water quality for parameters like pH, Color, Turbidity, FC and DO are within the limits of Sea Water Criteria (SW3)

6.3 Water quality standards for marine outfalls

(The Environment (Protection) Rules, 1986, Schedule I, S. No. 86.)

In a coastal segment marine water is subjected to several types of uses. Depending of the types of uses and activities, water quality criteria have been specified to determine its suitability for a particular purpose. Among the various types of uses there is one use that demands highest level of water quality/purity and that is termed a —designated best use in that stretch of the coastal segment. Based on this, primary water quality criteria have been specified for five designated best uses:-

Criteria of Sea Water Quality (Annexure-1 Standard for Sea Water Quality Criteria)

S. No.	Sea Water	Criteria
1	SW1	For Salt Pans, Shell Fishing, mariculture and Ecologically Sensitive Zone
2	SW2	For Bathing, Contact Water Sports and Commercial Fishing
3	SW3	For Industrial Cooling, Recreation (non-contact) and Aesthetics
4	SW4	For Harbour Waters
5	SW5	For Navigation and Controlled Waste Disposal

6.4 Disposal of treated domestic waste water

Existing sewage treatment plant

The sewage from the township is collected in the existing septic tank. Raw sewage is then pumped to the treatment plant with a capacity of 3 MLD. Treated sewage is partly recycled and reused for toilet flushing in the township. Any excess quantity of treated sewage is used for horticulture purposes or disposed through pipelines into the Arabian Sea. The sludge from the treatment plant is pumped to drying beds. The dried sludge is used as manure in the township

gardens for horticulture/afforestation. Scheme of Domestic Treated Waste water disposal is given in Figure 6.2.

Treatment Process

Septic tanks are used as a raw sewage sump and manual screens are provided on the upstream of the septic tank to arrest the floating matter. The raw sewage is pumped into the aeration tanks with submerged diffusers to develop the microorganisms to consume BOD. The aerated sewage flows over into the secondary clarifier- 1 where the suspended microorganisms are settle down and the clear liquid flows into the flash mixer tank. Coagulants are added to enhance suspended solids settling. Further settling takes place and clear liquid overflows from the top into the pressure filter feed sump.

The clarified sewage is then pumped from the pressure filter feed sump to the pressure sand filter where the remaining suspended solids and BOD are arrested. The outlet from the pressure filter is chlorinated and sent to the township for flushing purposes. Excess quantity of treated sewage is used for horticulture purposes or disposed through pipelines into the Arabian Sea. The solid settled in the bottom of the clarifier is recycled back into the aeration tank as return sludge. The excess sludge is periodically sent to the sludge drying bed for drying. The backwash of the pressure filter is routed back to the equalization tank. The filtrate from the sludge drying beds is pumped to the equalization tank. The dried sludge is used as manure for the gardens and other afforestation activities.

7.0 Ecological status of study area

7.1 General ecological assessment

The observations and assessment of overall ecological scenario presented in this chapter include details of flora, fauna, natural habitats, protected areas, wildlife species and their migration corridors etc. Such information provides better understanding of the situation and overall ecological importance of the area. This information can then be viewed against project activities for prediction of impacts on the wildlife and their habitats in the region.

7.2 Biogeographic zone

As per global classification defined by WWF, the region falls in the Indo-Malay Realm (IM 1303), Arabian Sea and Deserts and Xeric Shrublands Biome. The North-western Thorn Scrub Forests [IM1303] ecoregion represents a large expanse of degraded dry forest surrounding the Thar Desert. Neither exceptionally species-rich nor high in endemism, the ecoregion nevertheless harbours viable populations of antelopes.

As per classification of Indian Biogeographic zones by Rodgers et al. (2000), the coastal region of Saurashtra belongs to Biogeographic zone-8, whereas, Saurashtra region falls under Biogeographic Zone 4 - the Semi-Arid with the Biotic Province 4-B, Gujarat Rajawarah. Adjoining the desert are the semi-arid areas, a transitional zone between the desert and the denser forests of the Western Ghats. The natural vegetation is thorn forest. This region is characterized by discontinuous vegetation cover with open areas of bare soil and soil-water deficit throughout the year.

7.3 Forest type

As per the forest classification of Champion and Seth (1968), forest of Jamnagar/ Devbhumi Dwarka district classified as "Tropical Dry Deciduous Forest" type 5A. These forests thrive in the region having the rainfall between 300 mm to 600 mm.

7.4 Protected areas

There are two protected areas located within 10 km of the project site namely Marine National Park and Marine Sanctuary. The Gulf of Kutch, located on the west coast of India is an arm of the Arabian Sea, and separates the Saurashtra peninsula from the Great and Little Rann of Kutch. Marine National Park and Sanctuary are largely located in the intertidal zone along the coastal area of Devbhumi Dwarka, Jamnagar and Rajkot extending to 150 km length in the Gulf of Kutchh. The marine Sanctuary was declared in 1980 and the Marine National Park was declared in 1982. Total area of 457.92 km^2 is under the Marine Sanctuary and 162.89 km^2 is under the Marine National Park.

Flora of Marine National Park mainly consists of mangroves and array of marine algae, including some commercially important species of Agarophytes and Alginophytes. The coastal line of the Gulf is fringed with luxuriant growth of *Avicennia*, *Rhizophora* and *Ceriops* species of mangroves and *Salvadora*, *Ziziypus*, and Prosopis species are some of the terrestrial species found in that area. Sanctuary has more than 70 sponge species, 37 species of hard coral and 24 species of soft coral, 150-200 species of fish, 27 species of prawn, 30 species of crab, 200 species of mollusc, 3 species of sea turtle, 3 species of sea snake, 3 species of sea mammal, 94 species of aquatic birds and 78 species of terrestrial birds.

The high density and diversity in the Gulf of Kutch is due to the availability of different types of habitats like sandy, muddy, rocky calcareous sea bed and coral beds and mangroves in the relatively sheltered waters.

8.0 Soil classification

The quality of soil in Okhamandal Taluka is hard, sandy and saline. The base layer is made up of limestone/clay and is inherently saline in nature. Reddish and highly fossiliferous limestone (known as Dwarka beds) is exposed along the western coastline. These Dwarka beds are above the Gaj beds and limestone layers. The depth of the topsoil layer in Okhamandal varies from 2" to 36". The topsoil layer along the coastal bed is poor due to wind erosion. The soil along this belt is more or less sandy and loose. The topsoil conditions observed in Okhamandal are given in Table 8.1.

9.0 Prevailing marine environment

9.1 Climate

The climate in the region is broadly characterized under four seasons as follows:

Winter: December - February
Summer: March – Mid June
Monsoon: Mid June - September
Autumn: October - November

9.2 Physical processes

9.2.1 Tides

The tides in the Mithapur Bay are mixed semi-diurnal with two unequal high and two unequal low waters occurring in each tidal day. From the recorded tides at Okha the following tidal parameters with respect to the CD are established:

Level	Range (m)
MHWS	3.47
MHWN	2.96
MSL	2.04
MLWN	1.20
MLWS	0.41

The tidal water enters the Gulf from west south-west and influences the Mithapur Bay from northwest-west. The tide pertaining to the study periods for Okha Port from Indian Tide Tables are presented in Annexure-4.

9.2.2 Currents

Current records indicate the highest current speed of about 0.9 m/s. The root mean square velocity for the entire data set is 0.56 m/s. Net u component (along-shore) is 0.05 m/s in the direction of flood which indicates the net transport into the bay. The net v component (cross-shore) of 0.05 m/s which is very small suggests dominant flow in the EW direction. The maximum u component is 0.81 m/s during flood and 0.86 m/s during ebb. However, strong ebb components occur for less duration than the strong flood components. Strong v components are also discernible with maximum offshore component of 0.77 m/s and the maximum onshore component of 0.59m/s. This may be due to depth contours which curve in the area.

9.2.3 Tidal excursion

Tidal excursion which is useful while considering distribution of contaminants when released to marine waters is the average distance a particle travels from slack water to slack water due to tidal currents. The following excursion lengths (km) are computed based on drogue trajectories charted within the Mithapur Bay by releasing the drogue at different tidal phases.

Tide	Flood	Ebb
Spring	11.0	9.0
Average	8.0	6.5
Neap	4.7	4.5

9.2.4 Bathymetry

The area between the peninsular Okha region and Bet Shankhodar is a shallow region with relatively deep water pockets of >5 m depths while the remaining area strewn with rock outcrops. The general depths of < 2 m makes the bay a tricky area for navigation for even smaller size fishing crafts.

The area between the southern tip of Shankhodar Island and Kyu Point on the southern mainland is termed as the Mithapur Bay in this report. Depths of >7 m exist in two large pockets with fewer shoals compared to the western part of the bay leading to Okha Port.

10. Marine monitoring study

10.1 Plan of work

Marine monitoring study as per requirements of Terms of Reference issued by MOEF&CC was conducted by CSIR-CSMCRI during March' 2017. The sampling stations were decided based on previous survey carried out by the National Institute of Oceanography (CSIR-NIO), Goa. Sampling locations 1 to 8 were selected for the study as illustrated in Figure 10.1 with location No. 8 as the control site. The sampling from all the stations was done during low (LT) and high tide (HT) and their relative positions were recorded using a hand held global positioning system (GPS). Details of sampling locations are given in Table 10.1.The samples were collected from the surface (S) and bottom (B). The following parameters were analyzed.

Table 10.1 GPS locations of the sampling stations

Location	Latitude	Longitude
1	22º25'21.8"N	69º04'5.00"E
2	22º24'57.9"N	69º04'36.4"E
3	22º25'0.90"N	69º05'18.8"E
4	22º26'6.80"N	69º07'1.20"E
5	22º27'0.50"N	69º0.5'14.6"E
6	22º28'20.3"N	69º05'7.40"E
7	22º29'22.0"N	69º05'0.07"E
8	22º30'0.05"N	69º03'44.1"E

10.2. Seawater samples

(A) Physico-chemical parameters

Seawater & air temperature, turbidity, total suspended solids, salinity, silicate, chloride, pH, dissolved oxygen (DO), bio-chemical oxygen demand (BOD), NH_4-N, NO_2-N, NO_3-N, total-N, PO_4-P, total-P, chlorophyll-a, phaeophytin, petroleum hydrocarbons and trace metals (Zn, Pb, Cd, Co, Cr, and Cu) only for surface water samples.

(B) Phytoplankton: Only surface water samples

Phytoplankton count, major genera and generic diversity and Shannon Wiener Diversity Index (SWDI)

(C) Zooplankton: Only surface water samples

Zooplankton count; volume of zooplankton, major genera of zooplankton and group diversity and SWDI.

(D) Microbiology counts

Total viable count, total coliform, *Escherichia coli*, Vibrio, Aeromonas, *Pseudomonas* spp.

(E) Fisheries

Experimental trawling for fish catch was carried out in the study area. Data on fish landing was collected from relevant agencies, and commercial value estimated.

(F) Micro-and macro-algae

Seaweed and microalgae diversity in the area was studied.

10.3. Sea sediment samples

Sediment samples were collected from coastal as well as inter-tidal area.

(A) Physico-chemical parameters

Texture, total organic carbon (TOC) and heavy metals (Al, Cr, Mn, Fe, Co, Ni, Pb, Cu, Zn)

(B) Microbiology counts

Total viable count, total coliform, E. coli, *Vibrio* spp., *Aeromonas*, *Pseudomonas* spp.

(C) Benthic fauna

Numerical and biomass density per unit area, identification of species and species diversity.

10.4. Coral and mangrove study

Coral and mangrove species diversity and abundance in the coastal area were studied. The coastal vegetation including species diversity and density other than mangroves were also investigated. Detailed description of flora and fauna (terrestrial and aquatic) in the study area is given with special reference to rare, endemic and endangered species.

The overall impact on marine life was assessed on the basis of analyzing all above parameters.

11.0 Methodology

11.1. Physico-chemical parameters

11.1.1. Temperature

The seawater temperature was recorded on the spot by precision mercury thermometer.

11.1.2. Salinity

A suitable volume of the sample was titrated against silver nitrate (20 g/L) with potassium chromate as an indicator and the salinity was calculated using standard tables.

11.1.3. Dissolved oxygen

The dissolved oxygen (DO) in seawater samples were measured by Winkler method.

11.1.4. Biochemical oxygen demand

Biochemical oxygen demand (BOD) is a measure of organic material contamination in water, specified in mg/L. BOD is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials (e.g., iron, sulphites). Typically the test for BOD was conducted over a five-day period.

11.1.5. Total dissolved solids

Total dissolved solids (TDS) was measured PCSTestr 35 instrument after calibration with known concentration of NaCl (AR grade) stock solution.

11.1.6. Turbidity

The turbidity of seawater samples were measured by turbidity meter (HANNA, HI 93703).

11.1.7. pH

The pH was measured using a digital pH meter (ECIL-5652). Before measurement calibration was made by standard pH solution of 4, 7 and 10.4.

11.1.8. Total suspended solids

Total Suspended Solids (TSS) is the solids in water that can be trapped by a filter. TSS generally includes a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life. High TSS in a water body can often mean higher concentrations of bacteria, nutrients, pesticides, and metals in the water. These pollutants may attach to sediment particles on the land and be carried into water bodies with storm water. For estimation of TSS, the water sample is filtered through a pre-weighed filter. The residue retained on the filter is dried in an oven at 103 to 105°C until the weight of the filter no longer changes. The increase in weight of the filter represents the total suspended solids.

11.1.9. Nutrient parameters

The nutrient parameters such as nitrite, nitrate, ammonia and inorganic phosphate were analyzed calorimetrically using UV spectrophotometer (Shimadzu-1201).

11.1.9.1. Nitrite and nitrate

Nitrite (NO_2) in the sample was allowed to react with sulphanilamide in acid solution. The resulting diazo compound was reacted with N-(1-naphthyl)-ethylenediamine to form a highly colored azo-dye and the absorbance was measured at 543 nm. Nitrate (NO_3) was estimated as nitrite as above after its reduction by passing the sample through a column packed with amalgamated cadmium.

11.1.9.2. Ammonia

Ammonia (NH_4) in seawater is allowed to react with hypochlorite in moderately alkaline solution to form monochloramine, which in presence of phenol, and excess of hypochlorite, gives indophenol blue complex. The absorbance was measured at 630 nm. Total nitrogen represents all forms of dissolved inorganic and organic species of nitrogen. Organically bound nitrogen is completely decomposed to a mixture of ammonia and nitrate during alkaline persulphate digestion. The nitrate content of the sample after oxidation was finally determined after conversion to nitrite.

11.1.9.3. Inorganic phosphate

Inorganic phosphate (PO_4) was determined by adding acidified molybdate reagent to yield phosphor-molybdate complex which was then reduced with ascorbic acid to a highly colored blue compound which was measured at 882 nm. Total phosphorous represents all forms of dissolved inorganic and organic species of phosphorous. Organically bound phosphorous is

completely decomposed to phosphate by a strong oxidizing agent (potassium persulphate). Inorganic forms of lower oxidation state are also oxidized to inorganic phosphate.

11.1.10. Heavy metals

The seawater samples collected separately in clean plastic bottles for heavy metal analyses were filtered through a 0.45 µm Millipore membrane filter, acidified with concentrated HNO_3 to adjust its pH 2.0 and stored in a deep freezer.

11.2. Sediment

The superficial bed sediment from all the sampling transects was obtained by a Van Veen grab of 0.04 m^2 area. The sediment after retrieval was transferred to a polythene bag and preserved for further analysis at the laboratory. The sample was split into sand and silt-clay fractions on 62 µ sieve and the texture was determined. The percentage of organic carbon was determined by TOC analyzer (Elementar Liqui TOC). The heavy metal concentrations in sediment samples were analyzed by ICP-OES after microwave digestion while Hg was estimated after digestion using ICP-MS.

11.3. Petroleum hydrocarbon

Petroleum hydrocarbon (PHC) was extracted through hexane (solvent) in the separating funnel. Upper layer from the separating funnel was taken and allowed to evaporate in the rota-vapour followed by spontaneous evaporation. Final weight was considered as total PHC concentration.

11.4. Biological parameters

11.4.1. Pigments

The pigments were analyzed from known volume of water which was filtered through 0.45 µm filter paper. The filter paper was extracted with 90% acetone. For estimation of chlorophyll and pheaophytin, the acetone extract was spectrophotometrically analyzed between 630 and 750nm before and after dilute acid treatment. The pigment concentration was calculated using following formula.

$$Cholorophyll\ a\ (C_a) = 11.85\big(Absorbance_{664} - 1.54(Absorbance_{647})\big) - 0.08(Absorbance_{630})$$

$$Chlorophyll\ a\ (mg/L) = \frac{C_a \times Volume\ of\ acetone\ extract}{Volum\ eof\ sample}$$

$$Phaeophytin\ (mg/L) = \frac{26.7(1.7Absorbance_{665a} - Absorbance_{664b}) \times Volume\ of\ extract}{Volume\ of\ sample}$$

where 664b and 665a are the absorbance values of the acetone extract before and after acidification, respectively.

11.4.2. Phytoplanktons

The phytoplankton samples were collected from the surface of the water column during low and high tides at all stations by using clean plastic bucket. Hundred liters of seawater sample was concentrated to 250 mL by filtering through plankton net (20 µm pore size). The concentrated samples were immediately preserved by adding 5 mL of 40% formalin and 2 mL of Lugol's iodine at the site itself. In the laboratory the samples were concentrated by using centrifuge and made up to the final volume of 25 mL. Finally concentrated samples were preserved in 4% formalin prepared in seawater. These samples were subjected to qualitative and quantitative analysis of phytoplankton. For the quantitative estimation, Sedgewick Rafter counting cell was used and for qualitative identification microscopic examination was followed. The standard monographs and other published literature were used for identification (Husted, 1930; Peragallo, 1965).

11.4.3. Zooplanktons

The zooplankton in the samples were determined by filtering 100 liters of seawater through 300 µm pore size plankton net and the collected zooplankton samples were kept in 250 mL of seawater having 4% formalin. The samples were stored in wide mouth plastic bottles under dark conditions. The number of zooplankton in the samples were counted by using counting a chamber supplied by Hydro-Bios (Catalog No.435010) and identified microscopically.

11.4.4. Benthic fauna

The sediment for benthic fauna were collected from the sea floor using Van-Veen grab having an area of 0.0663 m^2. The collected sediments were made to slurry with seawater and sieved through 40-pore size (ASTM, 430 µm mesh size) sieve. The retained organisms on the sieve were preserved with 4% formalin in seawater for further studies. The benthic fauna were sorted to group level under microscope. After counting the individuals, fresh weight of each group was determined. The results were calculated and expressed as number or weight of benthos per m^2 area of the sea floor.

11.4.5. Microbiology (water and sediment)

For water microbiology 10 mL of water sample of different stations were collected in sterile falcon tubes and immediately stored in ice. The samples were carried to the laboratory within 3-4 h, subsequent plating was done in both selective (Eosine Methylene blue, TCBS, *Aeromonas* and *Pseudomonas* selective media) and non-selective (Zobell marine agar) media after suitable dilution. The plates were incubated for 48 h and the number of colonies was expressed in CFU/mL.

For sediment microbiology, 1.0 g of sterile bottom sediments were mixed with 0.9% NaCl and were plated onto both selective and non-selective media and incubated for 48 h. and the bacterial count were expressed in CFU/g.

12.0 Results and Discussion

12.1. Present water quality status

Water samples were collected from different station along with their GPS location and all physical, chemical and nutrient parameters like pH, turbidity, TSS, salinity, TDS, DO, BOD, ammonia, nitrite, nitrate, total nitrogen, silicate, PHC, phosphate and total phosphate were analyzed in the laboratory. The details of physical parameters are given in Table 12.1; inorganic parameters are given in Table 12.2 and nutrient parameters given in Table 12.3 to 12.5.

12.1.1. pH

The principal system that regulates pH of water is the carbonate system consisting of CO_2, H_2CO_3, HCO_3^- and CO_3^{2-}. Because of the buffering capacity of seawater, generally seawater pH has limited variability (7.8 to 8.3). In shallow, biologically active tropical waters, large diurnal pH changes from 7.3 to 9.5, may occur naturally because of photosynthesis. In near shore and estuarine systems influx of freshwater particularly during monsoon can affect the buffering effect and the pH often remains below 8.

The average pH of the Mithapur Bay and the open shore water varies in narrow ranges as evident from the location wise pH data given in Figure 12.1 and Table 12.1. The pH values during the study period show that pH at the DP, the Mithapur Bay and the open shore waters vary from 7.8 to 8.1. As expected, the temporal variations are small though systematic pattern is not discernible. The range of pH observations indicate the absence of any discernible influence of the treated waste water release of TCL on the pH of the Bay even in the vicinity of effluent release.

12.1.2. Total dissolved solids

TDS are the solids in water that can pass through a filter with a pore size of 0.45 µM. TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. TDS has a definite relation with salinity of sea water. A certain level of these ions in water is necessary for aquatic life. TDS of different stations varied from 42 to 48 ppt and there was no regular trend in its variation between the surface and the bottom sample or low and high tide samples. Location wise TDS results are given in Figure 12.2 and Table 12.1.

12.1.3. Total suspended solids

TSS of natural origin mostly contains clay, silt and sand of bottom and shore sediments, and plankton. For near shore areas, clay/silt/fine sand and vegetation matter form important component of TSS. Anthropogenic discharges add a variety of TSS depending upon the source. Since the major contribution comes from the disturbance of bed and shore sediments, energy of the region such as tidal currents is the vital influencing factor for TSS and typically leads to high values in the bottom water.

TSS includes all particles suspended in water which will not pass through a filter. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen. As levels of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. Organic content in TSS increases oxygen demand in the water column and

its settlement on the bed can make the sediment anoxic. Suspended particles also provide attachment places for pollutants such as metals and bacteria, offering them a free ride.

The monitoring results during the study period show that TSS content at the DP, the Mithapur Bay and the open shore waters vary from 11 to 41 mg/L. However there was no consistent trend for TSS value in different stations or different tides. Location wise TSS data are given in Figure 12.3 and Table 12.1. The highest TSS value found in station no: 6 i.e. 41 mg/L and the lowest value found in station number no: 1 i.e. 11 mg/L.

The seasonal as well as spatial variations are not marked and TSS in the bottom is generally higher than that in the surface indicating its source in the bottom sediment. The overall data do not indicate any significant influence of effluent-associated TSS on the Bay water quality.

12.1.4. Turbidity

There is high fluctuation on turbidity value in all the station with both tides. The total turbidity value among all stations varies from 3.47 to 18.38 NTU. The measured turbidity value near DP (station 2) was very low and the control site at station 9 recorded maximum turbidity. The turbidity at station 9 at high tide was 18.38 NTU in the bottom water while rest of the stations had turbidity in the range of 3.80 to 13.59 NTU. Location wise turbidity data are given in Figure 12.4 and Table 12.1.

12.1.5. Salinity

Salinity is an indicator of freshwater drainage in near shore coastal waters as well as excursion of saline water in inland water bodies such as estuaries, creeks and bays. Normally seawater salinity may vary depending on competition between evaporation and precipitation, and freshwater addition. Biota is generally acclimatized to a certain range of salinity where they thrive. Hence, wide changes in salinity can result in adoption with modification and dominance of selected species in the lower order while higher order biota may migrate.

The salinity is the total of all non-carbonate salts dissolved in water, usually expressed in parts per thousand (1 ppt = 1000 mg/L). Even though there are smaller quantities of other ions in seawater (e.g., K^+, Mg^{2+}), sodium and chloride ions represent appx 90% of all seawater ions. Since most anions in seawater or brackish water are chloride ions, salinity can be determined from chloride concentration.

In the absence of freshwater discharges, the salinity (ppt) of the study area is often high as evident from the results summarized in Figure 12.5 and Table 12.2. Salinity varied from 37 to 39 ppt which is normal for the Gulf of Kutch during summer season.

12.1.6. Chloride

Chloride, in the form of the Cl^- ion, is one of the major inorganic anions, or negative ions, in saltwater and freshwater. It originates from the dissociation of salts, such as sodium chloride or calcium chloride, in water. These salts, and their resulting chloride ions, originate from natural minerals, saltwater intrusion into estuaries, and industrial pollution. Since most anions in seawater or brackish water are chloride ions, salinity can be determined from chloride concentration.

In the present study, the chloride concentration was observed in the range from 18,794 to 21,993 mg/L. Location wise chloride data are given in Figure 12.6 and Table 12.2. However there was no consistent trend for chloride concentrations in different stations or different tides. The overall data do not indicate any significant influence of effluent-associated chlorides on the Bay water quality.

12.1.7. PHC

Oil enters the marine environment by a number of different routes as a result of both human activities and natural processes. By far, the biggest contribution comes from terrestrial source, mainly in the form of domestic and industrial wastes. There are several sources of petroleum hydrocarbons, however, human activities such as oil transportation and spills, shipping, industrial, storm water and domestic discharges are major sources of hydrocarbons in the coastal environment. The rate and extent to which oil dissolves, depend upon its composition, extent of spreading, water temperature, turbulence and rate of dispersal. The heavy components of petroleum are virtually insoluble in seawater whereas lighter compounds particularly aromatic hydrocarbons such as benzene and toluene, are slightly soluble. However, these components are also the most volatile and so are lost very rapidly by evaporation, typically 10 to 1000 times faster than by dissolution. Concentrations of dissolved hydrocarbons thus rarely exceed 1 mg/L even in areas receiving their fluxes.

In the present study, PHC value was comparatively very low in all the monitoring locations. This may indicate that the water pollution due to petrochemicals and other contaminants are negligible in this area. PHC ranged from 0.012-0.14 mg/L. Location wise PHC data are given in Figure 12.7 and Table 12.2.

12.1.8. Dissolved oxygen

DO content of water is a vital water quality parameter influencing the health of aquatic biota. Although there is considerable dispute on minimum level of DO required for a healthy tropical marine environment, it is considered that DO levels should not fall below 3 mg/L for prolonged periods in inshore waters. The sources of DO in natural waters are photosynthesis and dissolution from the atmosphere across the air-water interface. However, DO is consumed by respiration and decaying organic matter. Hence, an increase in oxidisable organic matter in water can deplete DO to levels which can be detrimental to aquatic life.

DO is the amount of gaseous oxygen (O_2) dissolved in the water. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement, or as a waste product of plant photosynthesis. Water temperature and the volume of moving water can affect dissolved oxygen levels. Oxygen dissolves easier in cooler water than warmer water. Adequate DO is important for good water quality and necessary to all forms of life.

In the present study, DO concentration was observed in the range 4.47 mg/L to 6.91 mg/L which describes the good quality of water in the study area. Location wise DO data are given in Figure 12.8 and Table 12.3.

12.1.9. Biochemical oxygen demand

In general, when there is an increase in the BOD levels, dissolved oxygen (DO) levels decrease because the oxygen available in water is consumed by bacteria or microorganisms to breakdown organic matter. In extreme situations DO can deplete to very low levels and even close to zero, the conditions under which the fishes and the other aquatic organisms may not survive. As per CPCB standard the amount of BOD permissible limit is 100 mg/L for discharge in marine coastal areas.

In the present study, BOD varies in the range of 2.1 to 6.1 mg/L indicating the absence of organic pollution. The BOD at DP is also in this range and as expected for the Gulf indicating that the TCL effluent has not increased the BOD of the bay. Location wise BOD data are given in Figure 12.9 and Table 12.3.

12.2. Nutrients

Dissolved nutrients though in low concentrations in natural surface waters play an important role in controlling production at the primary level and in turn the fishery potential of the area. Among several inorganic constituents such as phosphate, nitrogen compounds, silicon, trace metals etc, the traditional nutrients namely phosphorus and nitrogen compounds have a major role to play in primary productivity particularly in coastal waters where silicate and metals generally do not control primary productivity. However, their occurrence in high levels in areas of restricted water exchange such as creeks, bays and estuaries can lead to an excessive growth of algae which in extreme conditions results in eutrophication.

In the aquatic environment, nitrogen and phosphorus are two nutrients that are particularly important for the growth of plants and algae. The commonly designated nutrients are inorganic nitrogen compounds (NO^{3-}, NO^{2-} and NH^{4+}), phosphate (PO_4^{3-}) and silicate (SiO_4^{3-}). Total phosphorus (TP) and total nitrogen (TN) are also included because of their importance in relation to ecosystem analysis. Planktonic organisms (like diatoms) that help formation of shells of silicon compounds furthermore need dissolved silicon salts (SiO_2). The concentrations of nutrients are largely influenced by geology of the region and influx of fresh water and anthropogenic discharges.

Nitrite

Nitrogen cycle involving elementary dissolved nitrogen, its oxides like NO_3, NO_2 and reduced forms like $NH4^+$, NH_3; plays a significant role in sustaining life in aquatic environment. NO_3^- is the end product of oxidation and the most stable form at pH 7. The principal source of nitrogen in marine environment is nitrogen fixation to N_2O and NH_3 via atmosphere. NO_2^- occurs in seawater as an intermediate product of nitrate in microbial processes i.e. denitrification at low oxygen levels at which NO_2^- is further transformed into NH_3 and N_2 in anoxic conditions.

The concentration of $NO2^-$-N in natural coastal waters with good oxidizing conditions is generally below 2 µmol/l. High levels of nitrites are toxic to humans and animals, especially infants. It can enter the body as nitrate, a nutrient which is essential to plant growth, and be converted into nitrite, which disrupts the oxygen delivering ability of haemoglobin in the bloodstream. Nitrites are a salt or ester anion of nitrous acid, which can be naturally or artificially occurring in groundwater. Nitrites come from fertilizers through run-off water, sewage, and mineral deposits. It can also stimulate the growth of bacteria when introduced in high levels into a body of water.

In the present study, the nitrite concentration varied from 0.001-0.066 µM, which is much lower than the normal seawater range indicating good oxidizing conditions in the Mithapur Bay. Location wise nitrite concentration are given in Figure 12.10 and Table 12.4.

Nitrate

The concentration of nitrate in seawater is generally below 50 µM; being intimately linked with uptake by phytoplankton. In the present study, the nitrates concentration varied from 0.41 µM to 8.88 µM. The nitrate concentration varied with respect to different sampling points. These results indicate that nitrate in the bay is low during the present study appears to be due to its efficient uptake by phytoplankton with abundant availability of phosphate and low SS in the Bay. Location wise nitrate concentrations are given in Figure 12.11 and Table 12.5.

Total nitrogen

In the present study, the Total- Nitrogen concentration varied from 0.50 µM to 9.10 µM. Location wise Total Nitrogen contents are given in Figure 12.12 and Table 12.5.

Ammonia

Ammonia in small amounts is generally present as Ammoniacal-nitrogen (NH_3) in natural waters including seawater as a result of microbiological activity which causes the reduction of nitrogen-containing compounds. In the present study, The concentration off Mithapur was low 0.02-1.25 µM and in the range normally recorded for unpolluted coastal waters. Location wise concentrations of Ammonical Nitrogen are given in Figure 12.13 and Table 12.3.

Phosphate

Phosphorus as phosphate (PO_4^{3-}-P) is one of the major nutrients required for plant growth and essential for life. Anthropogenic sources of phosphate in a coastal marine environment include domestic sewage, detergents, effluents from agro-based and fertilizer industries, agricultural run-off, organic detritus such as leaves, cattle waste etc. Phosphorus in the form of phosphate is an essential plant nutrient and is a major component of most fertilizers. Erosion and runoff can result in transfer of phosphorus associated with fertilizers in significant amounts to inshore and coastal bodies of water and lead to eutrophication subject to availability of nitrate. These are some of the primary reasons that the monitoring of phosphate levels in water is extremely important.

The concentration of phosphate off Mithapur was generally below 3 µM though high values are occasionally encountered. Phosphate concentration varied considerably in different sampling stations. Interestingly in station 6 there was a high fluctuation of phosphate value for surface and bottom sample of HT. Similar trend was observed for total P also. Location wise concentration of phosphate is given in Figure 12.14 & 12.15 and Table 12.4 & 12.5.

Silicate

High value of silicate was observed in station 6 and station 7. The total value of silicate varied from 6.3 to 28.6 µM. The value was in between 6.4 to 11.9 µM in the station 1 to 3. Location wise Silicate data are given in Figure 12.16 and Table 12.4.

12.3 Heavy metal in sea water

Some metals including zinc (Zn), copper (Cu), iron (Fe) etc. are useful for human and animal health in minute doses beyond which these are toxic. Occurrence of heavy metals such as Cr, Pb, Cd and Hg in seawater is of concern because they tend to bioaccumulate in organisms including fishes and can be transferred to humans on consumption of sea food. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer.

The sea water samples were collected off Mithapur were analyzed for Cd, Co, Cr, Cu, Pb, and Zn as per standard methods. Results of heavy metals are given in Table 12.6.

Thus the heavy metals in sea water off Mithapur varied in the following ranges:

- Cd: 0.0 – 0.5µg/L (Figure 12.17)
- Co: 0.0 -1.1µg/L (Figure 12.18)
- Cr: 0.01 – 42.3 µg/L (Figure 12.19)
- Cu: 2.6 – 85.6 µg/L (Figure 12.20)
- Pb: 5.1 – 14.2 µg/L (Figure 12.21)
- Zn: 40 – 519 µg/L (Figure 12.22)

These concentrations are low and in the ranges expected for natural coastal waters indicating absence of anthropogenic contamination by heavy metals off Mithapur. The graphical representations of all heavy metals in different location for better understanding are given in Figures 12.17-12.22.

The Environmental (Protection) Rules 1986, [Schedule–VI] General Standard for discharging of Environmental pollutants in marine & coastal areas for heavy metals prescribes the limit for As, Hg, Pb, Cd, Cu, Zn, Ni, and Fe with the value of 0.2, 0.01, 2.0, 2.0, 3.0, 15, 5.0, 3.0 mg/L respectively.

12.4. Biological data

12.4.1 Water bacteriology

The total viable counts (TVC) in all eight sampling station vary between $10^4$and 10^5 CFU/mL. There is no regular trend of TVC counts among high tide and low tide samples. Control station 8 and 9 recorded comparatively high counts of TVC in comparison to the stations located near DP (Stations 1, 2 and 3).

Enterobacteria are bacteria from the family Enterobacteriaceae, which are primarily known for their ability to cause intestinal upset. Enterobacteria are responsible for a variety of human illnesses, including urinary tract infections, wound infections, gastroenteritis, meningitis, septicemia, and pneumonia. Some are true intestinal pathogens; whereas others are merely opportunistic which attack weakened victims. Members of the Enterobacteriaceae family form a very large group of morphologically and physiologically similar bacteria. Enterobacertiaceae are a large, heterogeneous group of gram-negative rod, non-spore-forming bacteria typically 1-5 µm in length and is one of the most important groups of bacteria. Some members of the Enterobacteriaceae (e.g., *Enterobacter* spp., *Escherichia coli*, *Citrobacter* spp. and *Klebsiella* spp.) can be recognized using methods that exploit their ability to ferment lactose rapidly. The family includes many genera (*Escherichia*, *Shigella*, *Salmonella*, *Enterobacter*, *Klebsiella*, *Serratia*, *Proteus* and others). More than 25 genera and 110 species or groups have been defined; however, the clinically significant Enterobacteriaceae comprise 20-25 species, and other species are encountered infrequently. For enterobacterial counts, selective media such as Eosin Methylene Blue (EMB) agar was used. The enterobacterial counts varied between 0 and 10^3 CFU/mL. Enteriobacteria were recorded both from surface (S) and bottom (B) of sampling stations 1 and 2. They were totally absent in station 3 and 4. Enterobacterial count was nil in HT samples of station 6, 7 and 8 (Table 12.7).

Vibrio spp. is other important group of bacteria present in the seawater samples. Number of *Vibrio* varied from 10^3 to 10^5 CFU/mL. Yellow colony formed in the TCBS plates were the dominant bacteria. They are generally considered as pathogenic. Therefore pathogenic Vibrios are dominating in the Mithapur water. Few green colonies were recorded in the station No. 4., *Aeromonas* sp. and *Pseudomonas* sp. considered to be other two pollution indicators were also studied in the present monitoring. Their counts varied from 0 to 10^4 CFU/mL.

12.4.2. Pigments

Chlorophyll, which has several forms, is capable of channelling the energy of sunlight into chemical energy through the process of photosynthesis. In photosynthesis, the energy absorbed by chlorophyll transforms carbon dioxide and water into carbohydrates and oxygen. The concentration of these photosynthetic pigments is commonly used to estimate phytoplankton biomass. Pheophytin a is a common degradation product of Chlorophyll a. Chlorophyll a and phaeophytin concentration of all the stations during HT and LT are include in Table 12.8. Chlorophyll a concentration was very low in control station 9. This station is located in the open ocean; therefore the concentration might be less. Maximum phaeophytin a concentration was recorded in station no 6 during HT which was followed by station 8 HT sample.

12.4.3. Phytoplanktons

Phytoplankton, also known as microalgae, are similar to terrestrial plants in that they contain chlorophyll and require sunlight in order to live and grow. Most phytoplankton are buoyant and float in the upper part of the ocean, where sunlight penetrates the water. Phytoplankton also requires inorganic nutrients such as nitrates, phosphates, and sulfur which they convert into proteins, fats, and carbohydrates. Phytoplankton forms the basis of life in the world's oceans. By converting sunlight and inorganic elements into plant tissue, these tiny cells begin the complex food web that ultimately sustains all marine fish, invertebrates, mammals and birds.

The diversity of plankton depends on physicochemical characteristics of water on the trophic level. In oligotrophic to mesotrophic waters, diversity of plankton is high while in mesotrophic and eutrophic conditions (indicating increasing pollution load), diversity of plankton decreases. Shannon Weaver Diversity Index (d) is a measure of diversity of plankton and takes into account the total as well as individual species count in a surface water sample.

$$d = - \Sigma (ni/n) \log2 (ni/n)$$

where,

ni = number of individuals of each species in the sample

n = total number of individuals of all species in the sample

The maximum values of Shannon Weaver Diversity Index (SWDI) of plankton for clean waters have been reported to be around 6, though it may differ in different locations. Decrease in the value of index may thus be taken as indictor of environmental stress. The index values of 3 and above are generally considered healthy condition of water bodies. The values between 1 and 3 and less than 1 are representative of semi and poor productivity respectively. SWDI of Mithapur water represented as semi or high. Station 6 and 9 indicated high SWDI and station 4 recorded low SWDI. Majority of the species includes *Climacosphenia elongate*, *Biddlphia* sp., *Coscinodiscus* etc. Location wise SWDI data are given in Figure 12.23 and Table 12.9.

12.4.4. Zooplanktons

Among zooplankton, maximum SWDI value (6.47) was recorded at station 4- LT sample. Calanoida was the dominant group followed by Herpacticoida and Nauplius larvae. Location wise SWDI data are given in Figure 12.24 and Table 12.10.

12.5. Sediment quality

The natural sediment of intertidal area of the Mithapur Bay has variable texture but generally composed of fine sand mixed with silt and clay. The subtidal sediment is highly heterogeneous and varies from coarse sand and calcareous debris to fine silt and clay. The available information on stratigraphy indicates that the strata below the thin surficial layer of sediment are in general of limestone underlain by very hard clay. The thickness of the limestone layer varies from about 3 m to more than 8 m.

The contents of trace metals, phosphorus, organic carbon and PHc transported through the effluent are low since the soda ash manufacturing process does not generate these constituents except those inherited from the raw materials namely limestone, salt and seawater. However, levels of phosphorus, organic carbon etc which may have the source in domestic effluents would enhance if such effluents are mixed with the industrial effluent. These include oils originating through spillages and leakages from compressors, pumps, cranes etc and residual fuel from vehicles as well as floor washings which if allowed in the industrial effluent has the potential to enhance PHc concentrations in the receiving water and ultimately the bed sediment when the residue gets associated with suspended particulate matter and sinks.

12.5.1. Heavy metals in sediment samples

Natural sediments always contain heavy metals to a varying degree depending on the source rock from which they are derived as well as the environment of deposition. This lithogenic contribution should be known fairly accurately to estimate probable increase due to anthropogenic

fluxes. The situation however is often complicated due to significant variations in concentration of metals in different areas of the given region primarily because of the grain-size effect with sediment having higher clay content often exhibiting higher levels of lithogenic metals. The grain size effect can be compensated to a certain extent by normalizing the metal value with aluminium which can be considered as a measure of clay content.

The sediment collected from the sampling stations off Mithapur were analysed for heavy metals namely Al, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn as per standard methods. The results are given in Table 12.11 and graphically illustrated in Figures 12.25 to 12.33. Most metals varied significantly in the study area as evident from the following ranges:

Al: 0.019 – 0.471 % (Figure 12.25)
Co: BDL – 3.4 mg/kg (Figure 12.26)
Cr: BDL – 55.2 mg/kg (Figure 12.27)
Cu:6.8 – 14.8 mg/kg (Figure 12.28)
Fe: 0.08 -0.781 mg/kg (Figure 12.29)
Mn:203.8 – 482.8 mg/kg (Figure 12.30)
Ni: BDL – 11.6 mg/kg (Figure 12.31)
Pb: 4.6 – 13.2 mg/kg (Figure 12.32)
Zn: 17.6 – 224.6 mg/kg (Figure 12.33)

The metals in sediment in coastal areas are generally lithogenic derived from the terrestrial source rock. Their concentrations in coastal sediment depend on several factors including clay, Fe, Al and Mn contents. The observed concentrations do not indicate any built-up of metals in the sediment off Mithapur due to anthropogenic inputs.

The above data reveal wide variations in the concentrations of metals. These variations are in part due to widely varying aluminium concentration. Also any particular trend is also not discernible between the subtidal and intertidal contents.

These results indicate considerable variations in metal: aluminium ratios suggesting that mechanisms other than particle size are also operative in the Mithapur Bay. Hence, it is critical that in future assessments of sediment quality and sampling sites are carefully selected, and collection is done from the same site during every sampling event.

12.5.2. Sediment microbiology

The total bacterial count was lower for the sediment samples in comparison to the seawater which is contrary to the general trend. This might be due to the rocky/sandy substratum which do not support good bacterial growth. Further organic load in the bottom sediments is also low. Among *Vibrio*, green colonies were recorded from sediment samples of all the stations. *Aeromonas*type bacteria were recorded from station 1 though they were absent at other locations (Tables 12.12).
Aeromonas Isolation Medium with *Aeromonas* Selective Supplement: *Aeromonas* Count
King's Medium Base: *Pseudomonas* Count

Pseudomonas type bacteria were isolated from four stations in low numbers, which indicate there was slight anthropogenic influence in the area.

12.5.3. Benthic organism

Diversity of benthic organisms was recorded from all the sampling stations. SWDI value was recorded to be maximum in station 5 (2.08), followed by station 3 (1.68) and station 8 (1.63). Abundance of bivalvia was maximum in station 5, followed by station 8. In the case gastropoda, maximum abundance was observed station 4 and station 2. Generic diversity was same for all the stations (Figure 12.34 and Table 12.13).

12.6. Seaweed diversity

Seaweeds are space occupiers of rocky shores, interact with other organisms, and hence play a key role in overall coastal biodiversity. Seaweeds, the larger and visible marine plants, are one of the important living resources of the ocean. These are found attached to rocks, corals, pebbles and other submerged strata in the intertidal and shallow sub-tidal zones of the sea. Based on the colour of their pigmentation, seaweeds are broadly classified into different classes such as Chlorophyceae (green), Phaeophyceae (brown) and Rhodophyceae (red). Seaweeds are also called macro-algae. This distinguishes them from micro-algae (Cyanophyceae), which are microscopic in size, often unicellular, and are best known by the blue-green algae that sometimes bloom and contaminate rivers and streams. Naturally growing seaweeds are often referred to as wild seaweeds, in contrast to seaweeds that are cultivated or farmed.

Seaweeds are important as food for human beings, feed for animals, fertilizer for plants and a source of chemicals and drugs. Algal products such as agar, carrageenan and alginates are being used in textiles, pharmaceutical, paper and pulp industries. The importance of seaweeds for human consumption is well known in many Indian Ocean countries such as Malaysia, Indonesia, and Korea, Australia etc. where these are used in salads, soups, jellies and vinegar dishes. Moderate to luxuriant growth of many species of green, brown and red algae occur along the Gujarat coast. In the present study, green algae such as *Ulva* sp., *Cladophora* sp., *Caulerpa racemosa*, brown algae such as *Iyengaia* sp. and *Ceramium rubrum* (red algae) were isolated and identified (Figure 12.35 and 12.36).

12.7. Flora and fauna biodiversity

Fauna diversity found at the study area during field study is as below:

No.	Name
1	Fox
2	Painted stork
3	Wader sp.
4	Seagull
5	Crow
6	Plover Sp.
7	Grey heron
8	Greater egret
9	Red Wattled Lapwing
10	Common Redshank

Birds found at the study area during field study are given in Figure 12.37.

The floras found in the study area are given in the Figure 12.38.

12.8. Macro-benthos

The term benthos refers to organisms that inhabit the substratum and just above overlaying water column at the bottom of an aquatic habitat. Included among the macro invertebrates are sponges, coelenterates, flatworms, nematodes, roundworms, annelids, molluscs, echinoderms, macro-crustaceans, insects and other invertebrates. Depending upon their size, benthic animals are divided into three categories namely microfauna, meiofauna and macrofauna.

In general the composition and density of benthos in marine waters are reasonably stable from year to year in unperturbed environments. However, seasonal fluctuations associated with life cycle dynamics of individual species may result in extreme variations at specific sites within any calendar year.

Benthic community responses to environmental perturbations are useful in assessing the impact of anthropogenic interventions on water quality. Assessing the impact of a pollution source generally involves comparison of benthic communities and their physical habitats at sites influenced by pollution with those from adjacent unaffected sites. The benthic communities can be characterized and compared according to community structure, density, biomass, diversity or other parameters like morphometrics, reproductive indices, growth etc.

Macrobenthic species which are considered for the present study are animal species with body size larger than 0.5 mm. The presence of species in given assemblages and its population depends on numerous factors, both abiotic and biotic. Most bottom communities have a characteristic species structure that is controlled by a few species which are abundant and thus called dominant species and are used to characterize benthic communities. Each species in a community has a certain level of tolerance which if exceeds, will adversely affect the communities. The community structure changes in response to rhythmic changes of physical environment are called the ecological succession.

Diversity of benthic organism observed at different stations is given in Table 12.13 and Figure 12.39 to 12.40.

12.9. Mangrove biodiversity in the intertidal area

Mangroves are diverse group of salt tolerant plant communities found in tropical and sub-tropical intertidal region of the world receiving rainfall between 1000 to 3000 mm and temperature ranging from 26°-35° C. Mangroves are commonly found throughout the world between latitudes 24° N and 38° S within tropical and subtropical sheltered coastal areas subjected to tidal influence. Mangroves are the most productive and biologically important forests having complex ecosystem and ecological importance and have recreational value. Mangroves are known to be the facilitators of photosynthesis in marine plant systems and are the breeding grounds as well as egg hatchery for the fishes. They play a vital role in nourishing the aquatic life by releasing certain nutrients due to the decomposition of the shed leaves. They help in the recharging the groundwater table and harbour diverse marine life systems such as amphibians, molluscs and water birds. Mangrove plants have highly branched network of rigid root system that helps in stabilizing and preventing the shore erosion. They help in the trapping of the debris and filter the sediments.

Mangroves cover is spread over an area of 4,740 sq km in India (Gujarat 1107 sq km, Jamnagar 173 sq km) accounting for nearly three percent of the world's mangrove vegetation (India State of Forest Report, 2015). Sparse to dense mangrove patches are present on the Gulf and those along the southern coast largely fall in the Marine National Park and Marine Sanctuary areas. *Avicennia* spp. (Cher) is the largest and most widespread of the three important mangrove species (*Avicennia marina*, *Avicennia officinalis* and *Avicennia alba*).

The intertidal area survey for the mangroves and the associated life systems were done on 24th March, 2017 over the coastline length of more than 10 km (from 22° 39' 82.7"N and 69°5' 43.4"E to 22° 40' 40.58"N and 69° 9' 89.30"E). A total of 5 different intertidal areas were sampled with 5x5 m quadrat for the studying the density of mangroves. The respective GPS coordinates of the intertidal areas along with the corresponding quadrats are included in the Table 12.14. The density of the mangrove vegetation is calculated using the following relation;

$$Density = \frac{Total\ number\ of\ individual\ of\ a\ species\ in\ all\ qudrats}{Total\ number\ of\ quadrats\ studied}$$

The most commonly recorded mangrove was *Avicennia marina* with branched root system and was scattered all over the study region. The size of these plants ranged from small, medium and large along with many emerging respiratory roots. The marshy intertidal area had several emerging respiratory roots. The density of *Avicennia marina* is expressed as plants per sq. metre (plants/m^2) and the corresponding values of densities are shown in Tables 12.15 to 12.16.

The emerging respiratory roots were dominantly found with a density of 3.09 plants/m^2 in IT1 followed by the medium sized plants (0.74 plants/m^2). Similarly, in other transacts (IT2 to IT5), the emerging respiratory roots were dominant and their density was higher when compared with the developed plants. The big plants of *A. marina* found in the IT2 and IT3 were characterized by thick branched shoot system and the heights were approximately 1.5 m. Photographs of *Avicennia marina* in the intertidal area are given in Figure 12.41.

12.10. Coral Reefs in Gulf of Kutchh

Coral reefs (Phylum, Cnidaria; Class, Anthozoa) are colonial organisms and they can secrete their own external calcium carbonate skeleton, thereby known as reef building corals (Hermatypic). Some corals are not reef building which are known as ahermatypic corals. Hard corals are also called as Scleractinian corals (sclera=hard). Coral reefs are one of the core ecosystems as it protect shores as well as provide breeding grounds for diverse groups of marine organisms. Corals are the richest depository which helps to maintain marine biodiversity.

Worldwide coral reefs are confined to the Atlantic, Indian and Pacific Oceans. In India, coral reefs are found in six major areas viz. Andaman Islands, Nicobar Islands, Gulf of Mannar, Palk Bay, Lakshadweep and Gulf of Kutchh (GoK).

Indian water harbour three types of corals namely:

A. Milleporan corals (Fire Corals) - GoK does not have any Millepora species of corals (Venkataraman et al., 2003)
B. Scleractinian corals (Hard corals) - Ahermatypic and hermatypic corals occur in Gujarat Coast including GoK.

Diversity of Scleractinian corals in GoK:

Details	Hermatypic	Ahermatypic
Families	8	2
Genera	20	3
Species	36	3

C. Alcyonarian Corals (Soft corals) - Alcyonarians and gorgonids occur off Veraval, off Dwarka, Gulf of Kutch, off Mundra and off Mandvi in Gujarat.

Coral atlas of Gujarat coast was published in 2011 under Integrated Coastal Zone Management Project jointly prepared by Gujarat Ecology Commission (GEC) and Bhaskaracharya Institute for Space Applications and Geo-Informatics (BISAG). Map showing Coral areas of GoK is given in Figure 12.42 as per Coral Atlas of Gujarat by the Gujarat Ecology Commission.

There are many islands adjoining the Okha coast and the Mithapur Bay. The major reef systems are Paga, Boria, Gora, Chandri, Bet Shankhodhar, Dholio Gugar, Dona, Mangunda and Savaj. The distribution of corals in these areas of Gulf of Kutchh is given in Table 12.17 (Pillai, C.S.G. and M.I. Patel, 1988). It is evident that forms like Pacillopora and Acropora are absent which is also a cause for their low diversity. The intertidal area of the Mithapur Bay is muddy/sandy and devoid of live corals since the prime requirement for corals to settle and grow is the presence of hard substratum.

During field studies a small patch of rocky shore (500m) was surveyed at Mithapur beach facing the Arabian Sea. Several scattered coral colonies were observed in this area during low tide. These corals were of hard type - mainly more than one species of Genus Porites and *Favites* sp. Zoanthids were also seen there, which are commonly found in coral reef environment (as shown in Photographs in Figure 12.43 (Corals observed in the study area). These coral seem to have relatively recently re-colonized the rocky shore and were in a healthy state. The reason for recovering/or presence of corals on Mithapur beach might be due to combined efforts of TCL in collaboration with Wildlife Trust of India and the State Forest Department To restore coral reefs in the Mithapur marine ecosystem and for the establishment of India‘s “Mithapur Coral Garden” which would house nearly all coral species found in the GoK.

12.11. Fish landing information in the related districts

Gujarat plays a leading role in production of marine fisheries in the country. There was a slow growth in marine fish production in the state (from 6,20,474 MT in 2000-01 to 6,95,580 lakhs MT in 2013-14). Inland fishery production was much less in Gujarat state. In 2000-01 inland production was just 40,591 MT and increased to 1,02,913 MT in 2013-14 (Fisheries Statistics of Gujarat, 2013-14).

Among district wise production, Junagarh recorded maximum landings of marine fish in 2013-14 amounting to 2,83,018 MT, followed by Porbandar (91,513 MT) and Jamnagar (68,065 MT) as given in Table 12 of Annexure-5. Nearest major marine fish landing centres to Mithapur are Dwarka and Okha, where total landing was recorded as 4,916 and 33,378 MT respectively in the year 2013-14 (Table 14 of Annexure-5). Among marine fish resources, small scienids (1,77,325 MT) are

the dominant species in Gujarat followed by Bombay duck (79,630 MT) and Ribbon fish (65,971 MT) as given in the Table 10 of Annexure-5. Gujarat had a major share in export of fish and fish product. In 2013-14, total fish and fishery product export from India was 9,83,756 MT out of which Gujarat's share was about one forth (2,51,920 MT) as given Table 32 of Annexure-5.

Regarding the inland fisheries resources, Jamnagar recorded 267 MT, Junagarh 591 and Porbandar 236 MT of total inland fish production in the year 2013-14 as given in the Table 31 of Annexure-5.

13.0 Overall impact on marine ecology

Geographically, the Mithapur Bay is located at the south western boundary of the Gulf of Kutchh. In the present study detailed analysis has been made on different water parameters both physical and chemical, since water quality generally controls diversity and sustainability of marine life. The salient findings emerging from these studies are as follows:

Overall Dissolve Oxygen, the most important water quality parameter that influences the integrity of marine habitats was high at all the station including the effluent release location of TCL. Evidently, Bio-Chemical Oxygen Demand was low and in the range commonly recorded in coastal marine zones, indicating the absence of anthropogenic organic pollution off Mithapur. Nitrogenous nutrient namely nitrate, nitrite and ammonia as well as phosphate were in low concentration as expected for natural coastal waters and did not indicate their elevation due to land-based sources.

Bacterial populations including the pollution indicator species like *E. coli*, *Vibrio* etc were in low numbers with sediment recording lower counts than in water. Total bacterial counts were in line with the general range of seawater. However, among Vibrio yellow colonies which were considered to be relatively pathogenic were recorded in water samples from all the stations and could be due to the vicinity of the Okha port and fishing activities.

The concentrations of heavy metals such as Cr, Co, Cu, Cd and Pb were low in water and sediment off Mithapur and appear to represent the baseline levels.

Chlorophyll a and Phaeophytin a concentration though varied were very low off Mithapur which might be due to low concentration of nitrogenous nutrients and/or high grazing pressure of zooplankton. Such temporal variations in phyto pigments are often recoded in coastal waters. Species diversity of both phytoplankton and zooplankton were relatively high supported by healthy water quality. Diversified seaweeds flora with representation of red, brown and green algae represented good light penetration and low turbidity of water.

The substratum along the Gulf coast of Mithapur is muddy/sandy, and as expected, corals were absent. However, along the Arabian Sea coast of Mithapur live corals including growing young colonies were found. Corals being very sensitive organisms, their occurrence supported good water quality of the region. Dense and sparse mangroves dominated by *Avicennia* species exist in the study area. Coastal birds like flamingo were seen in large number in the intertidal area, which are their feeding zones.

14.0 Conclusions

Marine environmental monitoring undertaken off Mithapur along the coast of the Gulf of Kutch and the Arabian Sea at 8 sampling stations resulted in the following conclusions:

- The pH, salinity and turbidity of seawater were typical of the coastal Gulf of Kutch.
- The water was highly oxygenated with high DO that would support diverse organisms. Consequently BOD was low revealing absence of anthropogenic organic contamination.
- The concentration of nitrogenous nutrients was low and probably a limiting factor for proliferation of phytoplankton when sufficient dissolved phosphate was available.
- The sea water quality parameters of the discharge point were compared with the findings from EIA conducted by CSIR-National Institute of Oceanography during March 2008.
- The parameters such as pH, salinity, PHC, DO and ammonia were found to be lesser when compared with the previous report and thus, it can be said that there is no such greater implications on the sea water characteristics.
- The levels of dissolved Cd, Co, Cr, Cu, Pb, and Fe were low and in the ranges expected for coastal waters free from heavy metal contamination. Their levels in sediment represented lithogenic background with no evidence for their built-up in sediments off Mithapur.
- Concentrations of Chlorophyll a and phaeophytin were low perhaps because of low concentration of nitrogenous nutrients and high grazing pressure of zooplankton. The SWDI suggested between semi and high phytoplankton diversity.
- The region sustained patches of mangroves dominated by *Avicennia* species which were in healthy condition.
- Corals were absent along the Gulf coast of Mithapur; the area being predominantly muddy/sandy. However, corals occur along the Arabian Sea coast of Mithapur.

Table 6.1: Standards for Treated Waste Water

Sr. No	Parameters	Prescribed Norms
1	pH	6.5 – 9.5
2	Temperature	40^0 C
3	Colour (pt. co.scale) in units	100 units
4	Suspended Solids	500 mg/L
5	Oil and Grease	2 mg/L
6	Ammonical Nitrogen	5 mg/L
7	Bio Assay Test	90% Survival of the fish after 96 hours in 100% effluent

Table 8.1 Topsoil conditions of Okhamandal

Depth of the soil	2”to 36”
Structure	Granular and Blocky
Texture	Sandy loamy/clayey
Water storage capacity	Poor to good
Penetration of water	Good to excellent
Looseness of soil	Good to excellent
Aeration	Moderate to good
Amount of organic matter present	Poor to good
Erosion factor	High
Colour	Light brown to dull black
pH	7.6-9.38
Salinity	0.002-7%

Source:http://www.gujenvis.nic.in/PDF/soil.pdf

Table 12.1 Physical parameters of seawater off Mithapur

S. No.	Station	Location	Tide	pH	Turbidity (NTU)	TSS (mg/L)	TDS (ppt)
1	8	S	LT	8.0	10.98		43.74
2		B		8.1	14.35		46.02
3	8	S	HT	8.0	14.52	39	46.31
4		B		8.1	18.38		45.55
5	7	S	LT	7.9	4.91		46.66
6		B		8.0	7.37		46.14
7	7	S	HT	8.1	6.01	28	44.44
8		B		7.8	5.85		46.19
9	6	S	HT	8.1	8.56	36	46.78
10		B		8.1	6.87		41.99
11	6	S	LT	8.1	3.80		46.19
12		B		8.1	8.84		47.13
13	5	S	HT	8.1	6.57	36	43.74
14		B		8.1	9.62		45.73
15	5	S	LT	8.1	6.07		46.43
16		B		8.0	7.21		45.73
17	4	S	HT	8.1	7.31	41	46.43
18		B		8.1	13.59		47.89
19	4	S	LT	8.1	6.00		44.09
20		B		8.1	7.94		47.24
21	3	S	HT	8.1	8.43	23	45.67
22		B		8.1	8.89		46.54
23	3	S	LT	8.1	6.16		48.30
24		B		8.1	6.52		45.90
25	2	S	HT	8.1	6.27	34	45.84
26		B		8.1	6.83		47.48
27	2	S	LT	8.1	3.47		45.38
28		B		8.0	4.35		48.06
29	1	S	HT	8.1	8.19	11	46.31
30		B		8.0	10.54		44.91
31	1	S	LT	8.1	7.59		43.27
32		B		8.1	7.36		47.71

Table 12.2 Different parameters of seawater off Mithapur.

S. No	Station	Location	Tide	Salinity ppt	Chloride (mg/L)	PHC (mg/L)
1	8	S	LT	37	19393.99	0.06
2		B		37	20193.74	
3	8	S	HT	38	19593.92	0.026
4		B		38	19593.92	
5	7	S	LT	37	20193.74	0.012
6		B		37	20793.55	
7	7	S	HT	38	19593.92	0.04
8		B		37	20393.68	
9	6	S	HT	37	20593.61	0.04
10		B		37	18794.17	
11	6	S	LT	39	20593.61	0.08
12		B		37	20393.68	
13	5	S	HT	37	19194.05	0.04
14		B		38	20193.74	
15	5	S	LT	37	20193.74	0.04
16		B		37	20393.68	
17	4	S	HT	37	18794.17	0.14
18		B		37	20793.55	
19	4	S	LT	38	19593.92	ND
20		B		38	20793.55	
21	3	S	HT	37	19793.86	0.02
22		B		38	20793.55	
23	3	S	LT	37	21993.18	0.012
24		B		37	19593.92	
25	2	S	HT	37	19993.8	0.04
26		B		38	20793.55	
27	2	S	LT	38	19993.8	0.08
28		B		38	21193.43	
29	1	S	HT	37	18794.17	0.012
30		B		38	20193.74	
31	1	S	LT	37	19793.86	0.04
32		B		37	20793.55	

ND-Not Detected

Table 12.3 Analyzed nutrient parameters of seawater

S. No	Station	Location	Tide	DO (mg/L)	BOD (mg/L)	Ammonia (µM)
1	8	S	LT	6.10	4.49	0.53
2		B		6.50	5.69	0.30
3	8	S	HT	5.69	5.30	0.20
4		B		6.10	4.00	0.30
5	7	S	LT	5.69	3.68	0.05
6		B		6.10	4.49	1.25
7	7	S	HT	6.10	BDL	0.23
8		B		6.50	6.10	0.41
9	6	S	HT	5.69	5.08	0.10
10		B		6.10	2.90	0.17
11	6	S	LT	6.10	4.08	0.35
12		B		6.50	5.30	0.28
13	5	S	HT	5.28	3.27	0.30
14		B		6.10	4.08	0.07
15	5	S	LT	6.91	5.30	0.82
16		B		6.50	4.49	0.38
17	4	S	HT	5.69	3.28	0.43
18		B		6.10	BDL	0.10
19	4	S	LT	5.28	2.87	0.15
20		B		5.28	3.67	0.15
21	3	S	HT	6.10	4.08	0.33
22		B		6.50	4.49	0.28
23	3	S	LT	5.28	3.27	0.38
24		B		6.10	3.68	0.02
25	2	S	HT	4.47	2.06	0.35
26		B		5.28	3.27	0.56
27	2	S	LT	5.69	4.08	0.41
28		B		6.10	4.08	0.05
29	1	S	HT	5.28	2.87	0.07
30		B		6.10	3.68	0.35
31	1	S	LT	5.28	3.27	0.53
32		B		6.10	3.68	0.58

Table 12.4 Analyzed nutrient parameters of seawater

S. No	Station	Location	Tide	Phosphate (µM)	Silicate (µM)	Nitrite (µM)
1	8	S	LT	1	18.5	0.050
2		B		0.3	8.9	0.046
3	8	S	HT	1.3	11.0	0.022
4		B		0.55	16.0	0.023
5	7	S	LT	0.6	18.2	0.042
6		B		0.5	14.6	0.049
7	7	S	HT	0.85	15.9	0.034
8		B		0.2	17.8	0.005
9	6	S	HT	0.8	11.0	0.037
10		B		0.45	9.9	0.030
11	6	S	LT	0.8	6.3	0.066
12		B		0.6	28.6	0.034
13	5	S	HT	2	25.1	0.001
14		B		13	17.9	0.011
15	5	S	LT	0.35	20.2	0.052
16		B		0.8	9.5	0.040
17	4	S	HT	0.3	7.4	0.024
18		B		1.55	11.8	0.015
19	4	S	LT	1.05	12.6	0.015
20		B		0.4	14.8	0.013
21	3	S	HT	0.5	6.4	0.027
22		B		1.35	9.1	0.026
23	3	S	LT	0.25	11.2	0.015
24		B		0.2	9.8	0.016
25	2	S	HT	0.6	9.9	0.026
26		B		0.8	11.3	0.034
27	2	S	LT	1.8	7.5	0.027
28		B		0.85	8.3	0.011
29	1	S	HT	1.4	11.9	0.019
30		B		0.5	9.5	0.033
31	1	S	LT	0.05	10.7	0.009
32		B		0	10.8	0.019

Table 12.5 Analyzed nutrient parameters of seawater

S. No	Station	Location	Tide	Total-P (µM)	Nitrate (µM)	Total-N (µM)
1	8	S	LT	1.95	6.18	6.76
2		B		2.95	7.06	7.406
3	8	S	HT	1.9	8.88	9.102
4		B		1.2	3.88	4.203
5	7	S	LT	1.15	6.35	6.442
6		B		1.7	1.35	2.649
7	7	S	HT	2.2	5.71	5.974
8		B		1.25	1.06	1.475
9	6	S	HT	2.2	4.47	4.607
10		B		4.4	1.41	1.61
11	6	S	LT	1.6	2.18	2.596
12		B		6.4	4.29	4.604
13	5	S	HT	2.5	1.47	1.771
14		B		22	1.71	1.791
15	5	S	LT	1.25	4.65	5.522
16		B		1.15	5.18	5.6
17	4	S	HT	1.4	0.76	1.214
18		B		2.15	0.41	0.525
19	4	S	LT	1.95	2.00	2.165
20		B		1.6	1.71	1.873
21	3	S	HT	13.7	2.94	3.297
22		B		1.35	2.12	2.426
23	3	S	LT	2.2	0.65	1.045
24		B		1	0.71	0.746
25	2	S	HT	1.4	5.88	6.256
26		B		19.85	1.47	2.064

27	2	S	LT	4	5.00	5.437
28		B		15.5	0.65	0.711
29	1	S	HT	4.85	0.41	0.499
30		B		7.8	5.06	5.443
31	1	S	LT	1.35	4.71	5.249
32		B		5.55	2.65	3.249

Table 12.6 Concentration of heavy metal in sea water

No.	Station name	Tide	Cd (μg/L)	Co (μg/L)	Cr (μg/L)	Cu (μg/L)	Pb (μg/L)	Zn (μg/L)
1	1	HT	0.2	0	11.9	7.9	9.4	154.2
2		LT	0.1	0	7.8	70.6	10.6	49
3	2	HT	0.4	1.1	42.3	6.7	8.3	178.9
4		LT	0.2	0.8	32.8	5.3	6.9	136.7
5	3	HT	0.2	0.3	10.5	2.6	5.1	40.1
6		LT	0.5	0	11.4	4.6	8	178.1
7	4	HT	0.3	0.1	0.010	7.4	10.1	147.5
8		LT	0.4	0	11.5	4.2	10.3	195.7
9	5	HT	0.4	0	12.9	3	8.6	193.3
10		LT	0	0	14.2	4.8	9.3	157
11	6	HT	0.4	0	12.5	8.8	7.1	236.7
12		LT	0.3	0.7	31.1	85.6	14.2	519.2
13	7	HT	0	0	15.5	4.6	10.4	126.7
14		LT	0	0	9.9	8.8	11.4	53.5
15	8	HT	0.2	0	11	6.9	8.2	182.1
16		LT	0.3	0	0.3	3.2	6	144.5

Table 12.7 Microbial Parameters- Bacterial Count (CFU/mL)

	1		2		3		4	
	HT	LT	HT	LT	HT	LT	HT	LT
Total Count (ZMA)	$3x10^4$	$1.2x10^5$	$3x10^4$	$4.8x10^4$	$6.6x10^4$	$5.4x10^4$	$6x10^4$	$5.2x10^4$
Enterobacterial Count (EMB)	$6.8x10^2$	$4.3x10^2$	$1.52x10^3$	$1.16x10^3$	$5.3x10^3$	0	0	0
Vibrio Count (TCBS)	$1.4x10^4$	$1.08x10^5$	$1.82x10^4$	$8.04x10^3$	$7.6x10^3$	$1.104x10^{14}$	$5.5x10^4$	0
Aeromonas Count	$3.48x10^3$	$5.4x10^2$	$8x10^3$	$4.17x10^3$	$2.51x10^3$	$1.76x10^3$	$4.05x10^3$	0
Pseudomonas Count	$8x10^3$	$5x10^2$	$2x10^4$	$2.08x10^3$	$5.2x10^3$	$6.5x10^2$	$8x10^1$	$3.9x10^2$

	5		6		7		8	
	HT	LT	HT	LT	HT	LT	HT	LT
Total Count (ZMA)	$6.2x10^4$	$2x10^4$	$1.5x10^5$	$2x10^5$	$6.3x10^4$	$2.5x10^5$	$1.39x10^5$	$7x10^5$
Enterobacterial Count (EMB)	0	$1.14x10^3$	0	$1x10^1$	0	$2.6x10^3$	$2x10^1$	$1.18x10^3$
Vibrio Count (TCBS)	$1.508x10^4$	$9.84x10^3$	$1.2x10^5$	$5.4x10^4$	$1.524x10^4$	$8.2x10^4$	$1.968x10^4$	$1.66x10^5$
Aeromonas Count	$1.61x10^3$	$3.57x10^3$	$1x10^1$	$4.2x10^3$	$2.84x10^3$	$5.28x10^3$	$4.32x10^3$	$3x10^3$
Pseudomonas Count	$6.8x10^2$	$2.25x10^3$	0	$4.6x10^3$	$3.2x10^2$	$3.48x10^3$	$6x10^1$	$2.3x10^4$

Table 12.8 Chlorophyll and phaeophytin-a of different stations

No.	Station name	Tide	Chlorophyll-a (mg/L)	Phaeophytin-a (mg/L)
1	1	HT	0.001	0.002
2		LT	0.005	0.009
3	2	HT	0.003	0.001
4		LT	0.002	0.006
5	3	HT	0.001	0.002
6		LT	0.002	0.000
7	4	HT	0.005	0.003
8		LT	0.008	0.002
9	5	HT	0.009	0.022
10		LT	0.000	0.001
11	6	HT	0.004	0.000
12		LT	0.000	0.002
13	7	HT	0.008	0.011
14		LT	0.003	0.000
15	8	HT	0.000	0.010
16		LT	0.000	0.011

Table 12.9 Diversity of phytoplanktons observed at different stations

No.	Station name & Tide	1		2		3		4	
		HT	LT	HT	LT	HT	LT	HT	LT
	Name of Species	No./L							
1	***Biddulphia* sp.**	-	-	-	-	-	1.15	5.40	2.88
2	***Brown algae***	-	-	-	-	-	-	0.90	-
3	***Coscinodiscus***	6.88	3.72	-	-	-	-	-	-
4	***Ceratium* sp.**	-	-	-	-	1.92	-	-	-
5	***Climacosphenia* sp.**	0.86	-	2.19	1.58	1.28	-	-	-
6	***Green algae***	-	0.93	-	-	-	-	-	-
7	***Ectocapus algae***	-	-	-	0.79	-	-	-	-
8	***Nevicula***	-	1.86	-	-	-	-	-	-
9	***Oscillatoria* sp.**	-	-	-	-	-	1.15	-	-
10	***Thlassionema nitzschioides***	0.86	-	-	-	-		-	-
-	**Generic diversity**	**3**	**3**	**1**	**2**	**2**	**2**	**2**	**1**
-	**SWDI**	**1.89**	**2.6**	**1**	**1.89**	**1.96**	**2**	**1.51**	**1**

No.	Station name & Tide	5		6		7		8	
		HT	LT	HT	LT	HT	LT	HT	LT
	Name of Species	No./L							
1	***Biddlphia* sp.**	0.97	-	0.67	-	-	-	-	-
2	***Chaetocero* ssp.**	-	0.56	-	-	-	-	-	-
3	***Coscinodiscus***	0.97	0.56	-	-	1.62	-	3.16	-
4	***Climacosphenia sp.***	1.94	-	-	-	-	1.34	0.79	-
5	**Egg**	-	-	-	0.74	-	-	-	-
6	**Green algae**	-	-	0.67	-	4.05	-	0.79	-
7	***Nevicula***	-	-	-	-	-	-	-	0.58
8	***Planktoniella***	-	0.56	-	-	-	-	-	-
9	***Synedra***	0.97	-	2.01	-	-	-	0.79	-
-	**Generic diversity**	**4**	**3**	**3**	**2**	**2**	**1**	**4**	**1**
-	**SWDI**	**3.79**	**3**	**2.59**	**1.75**	**1.82**	**1**	**3.17**	**1**

Table 12.10 Diversity of zooplanktons observed at different stations

No.	Station name	1		2		3		4	
		HT	LT	HT	LT	HT	LT	HT	LT
	Name of Species	No./L							
1	*Calanoida*	5.94	4.60	1.66	4.98	1.80	3.24	10.00	7.40
2	*Cyclopoida*	-	6.9	0.83	0.83	-	4.86	1.00	1.48
3	*Copepoda*	-	-	-	-	-	1.62	-	-
4	*Egg*	-	3.45	-	-	-	-	-	-
5	*Gastropod larvae*	-	-	-	-	-	-	-	1.48
6	*Herpacticoida*	0.66	1.15	3.32	1.66	1.20	2.43	2.00	-
7	*Naupliuslaravae*	1.98	-	1.66	1.66	-	7.29	5.00	2.22
8	*Ostracoda*	0.66	12.65	-	-	-	-	-	-
9	*Polychaete larvae*	-	-	-	1.66	-	-	-	0.74
10	*Tintinnid*	-	-	0.83	-	0.60	0.81	1.00	2.22
11	*Veliger larvae*	0.66	1.15	0.83	0.83	-	-	-	1.48
12	*Worm*	-	-	-	-	-	-	-	0.74
13	*Zoea larvae*	-	-	-	-	-	-	-	0.74
-	Generic diversity	5	6	6	6	3	6	5	9
-	Vol. of Zoo.(mL/L)	0.66	1.15	0.83	0.83	0.60	0.81	1.00	0.74
-	Biomass (g/m³)	0.0003	0.0007	0.0005	0.0005	0.0004	0.0002	0.0004	0.0008
-	SWDI	3.22	1.49	5.16	4.83	2.75	4.9	3.44	6.47

No.	Station name & Tide	5		6		7		8	
		HT	LT	HT	LT	HT	LT	HT	LT
	Name of Species	No./L							
1	*Calanoida*	1.80	1.76	2.10	1.48	-	0.62	1.04	2.56
2	*Cyclopoida*	-	-	2.10	0.74	1.00	0.62	-	0.64
3	*Herpacticoida*	2.70	1.76	1.40	1.48	-	-	-	-
4	*Nauplius larvae*	0.90	-	1.40	-	3.00	1.24	0.52	0.64
5	*Polychaete larvae*	-	-	-	-	-	-	0.52	-
6	*Sabellaria larvae*	-	-	-	-	1.00	-	-	-
7	*Tintinnid*	-	-	0.70	-		-	-	-
8	*Veliger larvae*	-	0.88	-	1.48	2.00	-	-	-
-	Generic diversity	3	3	5	4	4	3	3	3
-	Volume of zooplankton (mL/L)	0.90	0.88	0.70	0.74	1.00	0.62	0.52	0.64
-	Biomass (g/m³)	0.0003	0.0004	0.0003	0.0002	0.0004	0.0004	0.0002	0.0003
-	SWDI	2.75	2.87	4.70	3.86	3.59	2.83	2.83	2.38

Table 12.11 Heavy metal content of the sediments

No	Station name	Tide	Al (%)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (%)	Mn (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
1	1	HT	0.278	2.2	25.2	13.2	0.676	482.8	11.6	12.80	23.8
2	2	HT	0.252	3.4	55.2	6.8	0.693	340.6	10.4	11.60	17.6
3	3	HT	0.234	0.4	16	10.4	0.49	443.2	7	13.20	224.6
4	4	HT	0.471	3.4	26.6	12	0.781	225	10	12.40	33.6
5	5	Sediment was not collected because of the rocky bottom									
6	6	LT	0.019	BDL	0.6	14.8	0.080	203.8	BDL	9.40	41.8
7	7	HT	0.133	1.8	22.2	10.4	0.680	279.8	11	9.80	48.6
8	8	LT	0.031	BDL	BDL	9.6	0.067	366.4	0.2	4.60	37.4

BDL-Below Detection Limit

Table 12.12 Microbial parameters- Bacterial Count (CFU/g)

Parameter	1	2	3	4	5	6	7	8
	HT	HT	HT	HT	HT	HT	HT	HT
Total Count (ZMA)	$6x10^4$	$1.2x10^4$	$2x10^4$	$4x10^4$	Sediment was not collected because of the rocky bottom	$1x10^2$	$>10^5$	$6x10^2$
Enterobacterial Count (EMB)	0	0	0	0		0	0	0
Vibrio count (TCBS)	$1.63x10^4$	0	$6x10^2$	$1.6x10^3$		0	$1.392x10^4$	0
Aeromonas count	$1x10^2$	0	0	0		0	0	0
Pseudomonas count	$1x10^2$	0	0	$4x10^2$		0	$5x10^1$	$3.5x10^2$

Zobell Marine Agar
EMB: Eosine Methylene Blue Agar
TCBS: Thiosulfate Citrate Bile Salts Sucrose Agar, Y =Yellow colony, G= Green colony

Table 12.13 Diversity of benthic organism observed at different stations

No.	Station name	1		2	3	4	5	6	7	8
		HT	LT	HT	HT	HT	LT	LT	LT	LT
	Name of Species	No./m²								
1	***Bivalvia***	2499.9	1249.9	2812.4	3749.9	5312.4	5624.9	1249.9	312.5	4062.4
2	***Dentalium***	16874.7	10312.3	14999.8	38124.5	14999.8	2187.2	1249.9	13124.8	12187.3
3	***Gastropoda***	149998.0	98748.7	204997.3	196247.4	211559.7	21874.7	34687.0	106873.6	98436.2
-	***Generic diversity***	3	3	3	3	3	3	3	3	3
-	**Numeric Density (No./m²)**	169372.8	110311.0	222809.6	238121.9	231872.0	29686.9	37187.0	120310.9	114686.0
-	**SWDI**	1.49	1.45	1.37	1.68	1.42	2.08	1.34	1.44	**1.63**

Table 12.14 Intertidal area sampling location details

S. No.	Transact Name	Quadrats	GPS location
1	IT1	Q1	N 22° 39' 82.7", E 69° 5' 43.4"
		Q2	N 22° 39' 79.11", E 69° 5' 43.58"
		Q3	N 22° 39' 77.28", E 69° 5' 49.31"
		Q4	N 22° 39' 64.7", E 69° 5' 65.5"
2	IT2	Q1	N 22° 38' 90.8", E 69° 7' 56.3"
3	IT3	Q1	N 22° 39' 30.1", E 69° 8' 68.75"
4	IT4	Q1	N 22° 39' 24.4", E 69° 8' 84.65"
5	IT5	Q1	N 22° 40' 33.7", E 69° 9' 94.7"

Table 12.15 Density of *Avicennia marina* vegetation found in the IT1

No.	Species	No. of plants	Density (plants/m²)
IT1 (No. of quadrats-04)			
1	Big plants	21	0.21
2	Medium sized plants	74	0.74
3	Emerging respiratory roots	309	3.09

Table 12.16 Density of *Avicennia marina* vegetation found in the IT2 to IT5

No.	Species	No. of plants	Density (plants/m²)
IT2 (No. of quadrat-01)			
1	Big plants	11	0.44
2	Medium sized plants	120	4.8
3	Emerging respiratory roots	87	3.48
IT3 (No. of quadrat-01)			
1	Big plants	5	0.05
2	Medium sized plants	10	0.10
3	Emerging respiratory roots	200	2.0
IT4 (No. of quadrat-01)			
1	Big plants	11	0.44
2	Medium sized plants	28	1.12
3	Small sized plants	15	0.6
4	Emerging respiratory roots	200	8.0
IT5 (No. of quadrat-01)			
1	Big plants	2	0.08
2	Medium sized plants	6	0.24
3	Small sized plants	21	0.84
4	Emerging respiratory roots	300	12.0

Table 12.17: Distribution of corals in the Gulf of Kutchh

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Esammocora digitata	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Acropora humilis	-	-	+	+	-	-	+	+	-	-	-	-	-	-	-
A.squamosa	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Montipora explanata	+	-	+	+	-	+	+	-	+	+	+	+	+	+	+
M.venosa	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
M.turgescons	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
M.hispida	+	+	-	+	+	-	+	+	+	+	+	-	-	-	+
M.foliosa	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
M.monasteriata	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
Coscinaraea monile	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+
Siderastrea savignyana	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudosiderastrea tayami	+	-	-	-	-	-	+	+	+	+	+	+	+	+	+
Goniopora planulata	+	+	-	-	+	+	+	-	+	+	-	+	-	-	+
G.minor	-	-	-	+	-	-	+	-	-	-	-	-	-	-	+
G.nigra	+	+	-	+	+	+	+	-	-	+	-	-	-	-	+
Porites leutea	+	+	+	+	-	-	+	-	-	-	-	+	-	-	+
P.lichen	+	-	-	-	-	-	+	-	+	-	-	+	-	+	+
P.compressa	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+
Favia speciosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
F.favus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Favites complanata	+	+	+	+	+	+	+	-	-	+	-	-	-	+	+

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F. melicerus	+	-	+	-	-	-	-	-	+	-	-	-	-	+	+
Goniastrea pectinata	+	+	+	+	+	+	+	-	+	+	+	-	+	+	+
Platygyra sinensis	+	+	+	+	-	-	-	-	-	+	-	-	-	+	+
Hydnophora exesa	+	+	+	+	-	-	-	-	-	+	-	-	+	-	+
Plesiastrea versipora	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
Leptastrea purpurea	-	-	-	-	-	-	-	-	-	-	-	Sikka point			
Cyphastrea serailia	+	+	+	+	+	+	+	+	+	+	-	-	+	+	+
Symphyllia radian	-	+	-	+	-	+	-	-	+	-	-	-	-	-	-
Acanthastrea simplex	+	+	+	+	-	-	-	-	+	+	-	-	-	-	+
Mycedium elephantotus	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Paracyathus stokesi	+	-	-	-	-	-	-	-	-	-	-	-	-	10	m
Polycyathus verrilli	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-
Tubastraea aurea	+	+	+	+	+	-	-	-	+	+	-	-	-	-	-
Turbinaria crater	+	+	-	+	-	-	+	-	-	-	-	-	-	-	+
T.peltata	-	+	+	+	+	+	+	-	-	+	-	-	+	+	+

1 : Okha 2 : Dholio Gugar 3 : Dona
4 : Boria 5 : Mangunda 6 : Savaj
7 : Paga 8 : Manmarudi Langamarudi 9 : Ajad
10 : Bural reef 11 : Dhani 12 : Kalumbhar reef
13 : Narara reef 14 : Goose reef 15 : Pirotan island

Source: Pillai, C.S.G. and M.I. Patel (1988)

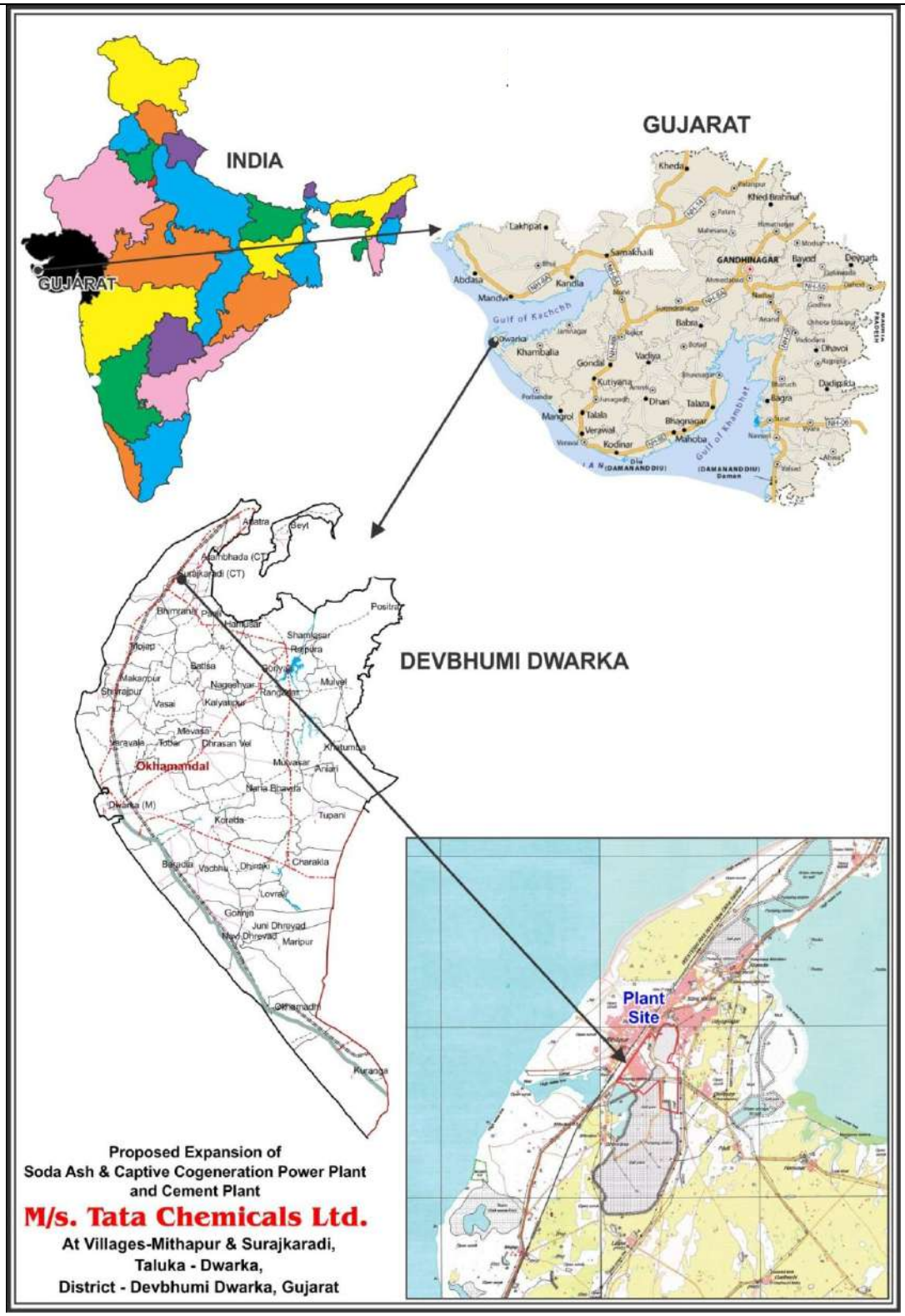


Fig.: 3.1 Location Map

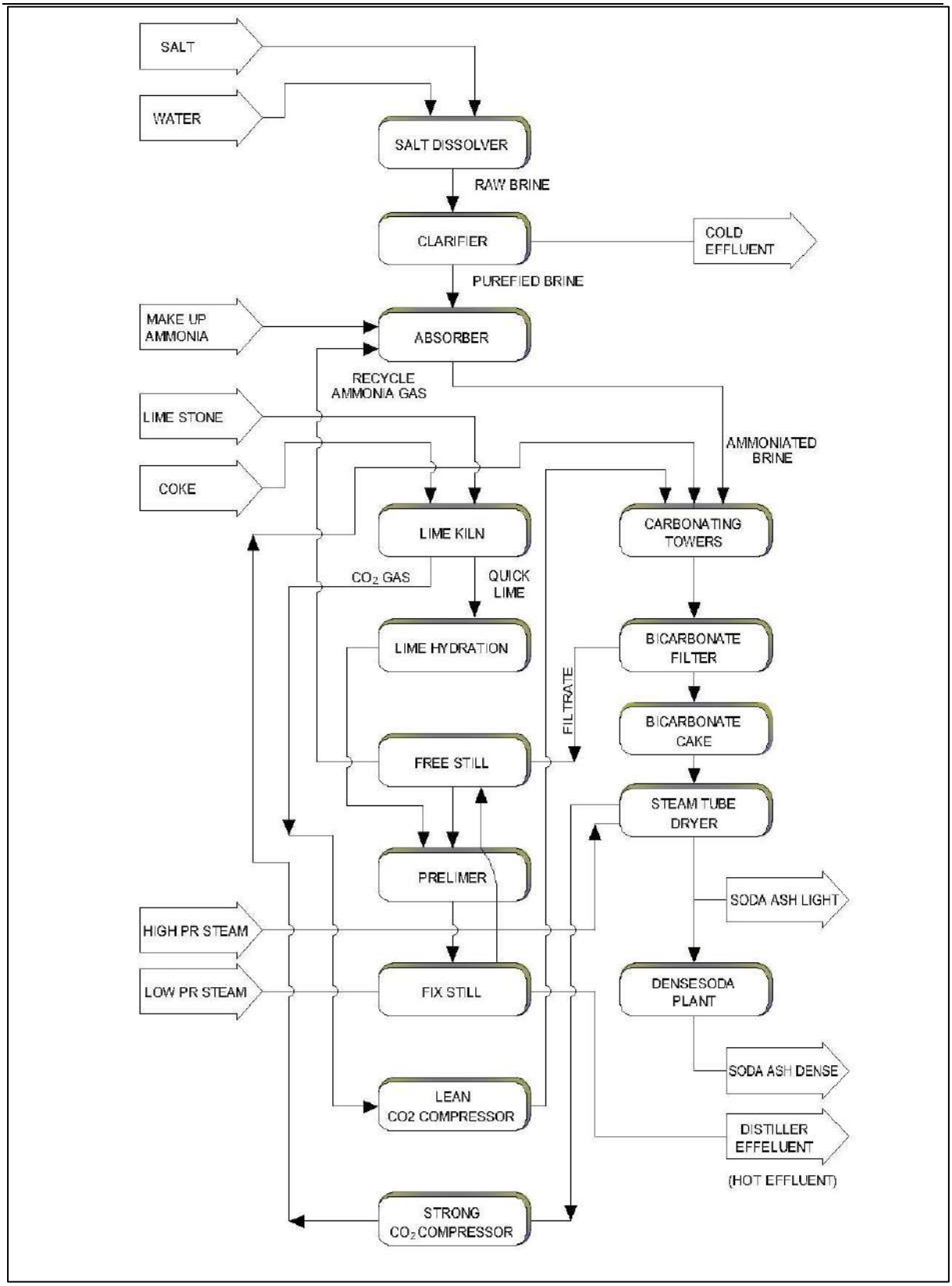


Figure 4.1 Process flow diagram for soda ash plant

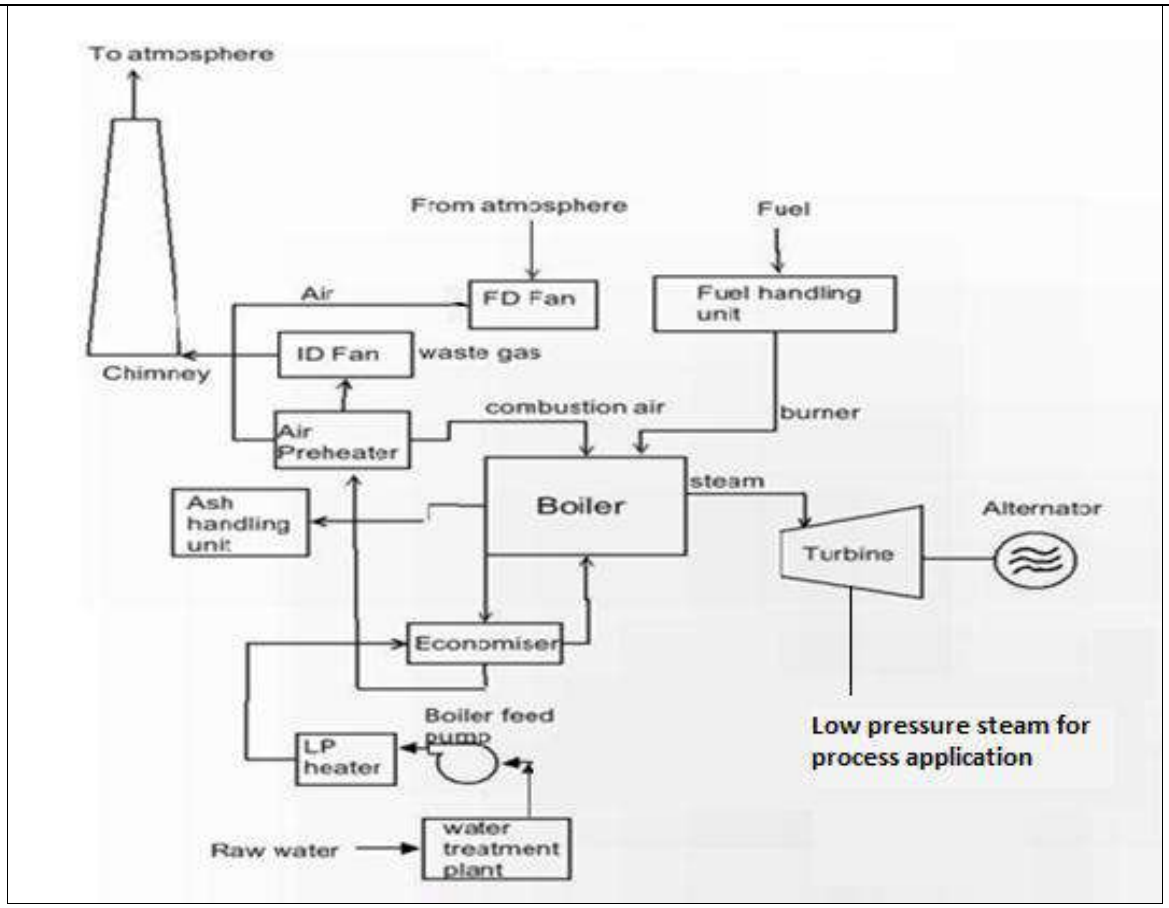


Figure 4.2 Process flow diagram-Captive cogeneration power plants

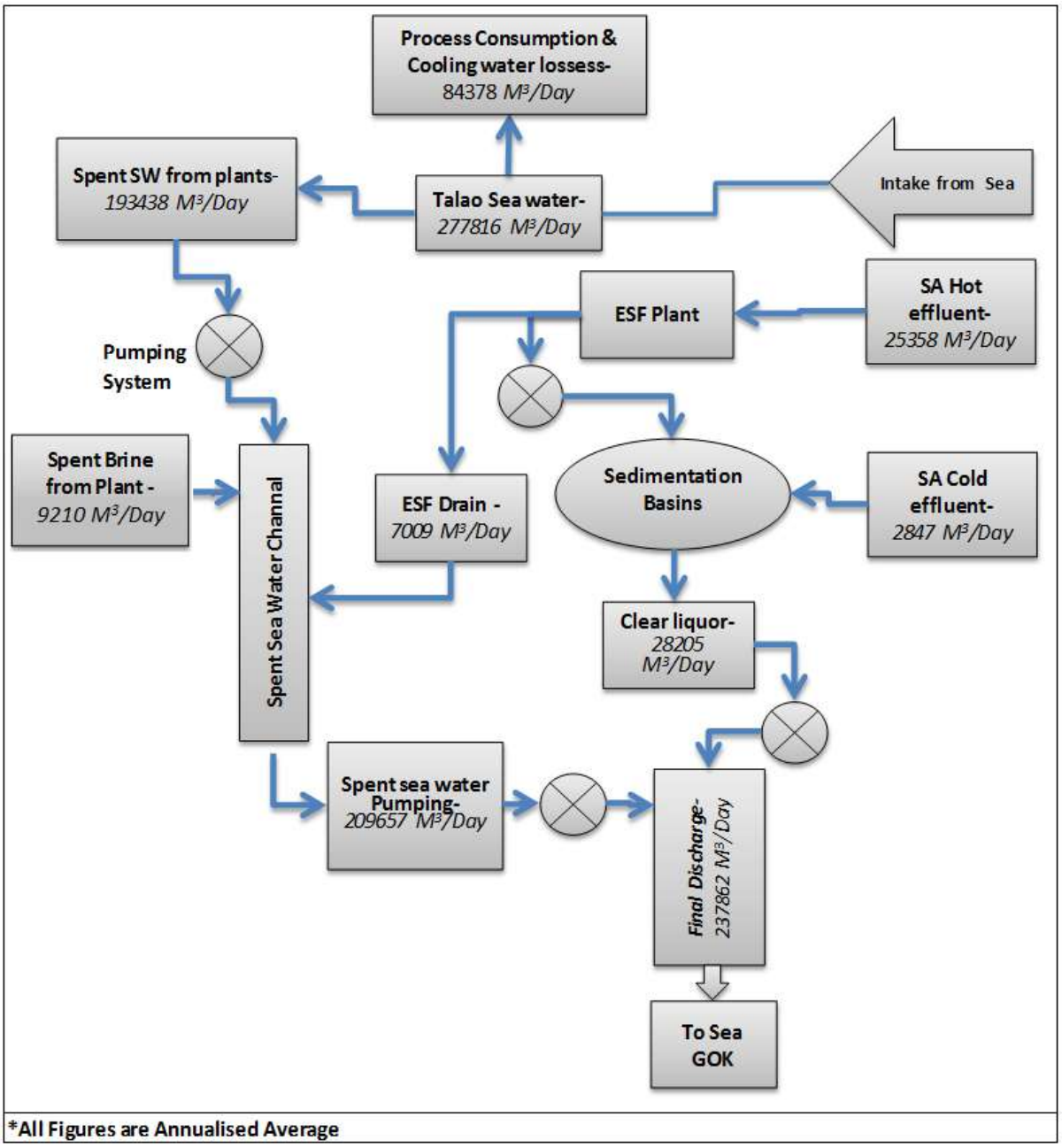


Figure 6.1 Treated waste water disposal scheme-Industrial

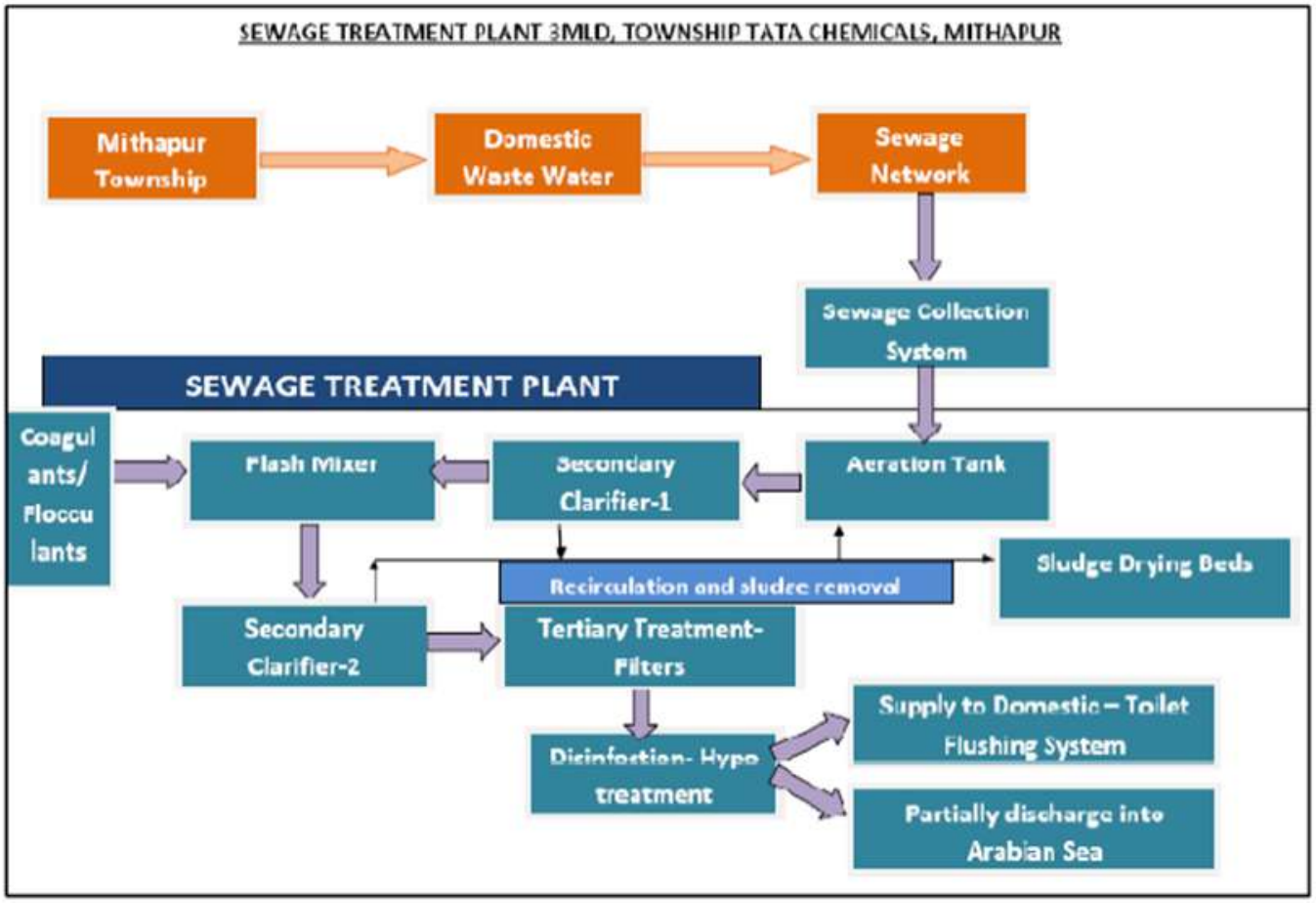


Figure 6.2 Treated wastewater disposal scheme-Domestic

Figure 10.1 Different sampling stations chosen for the study

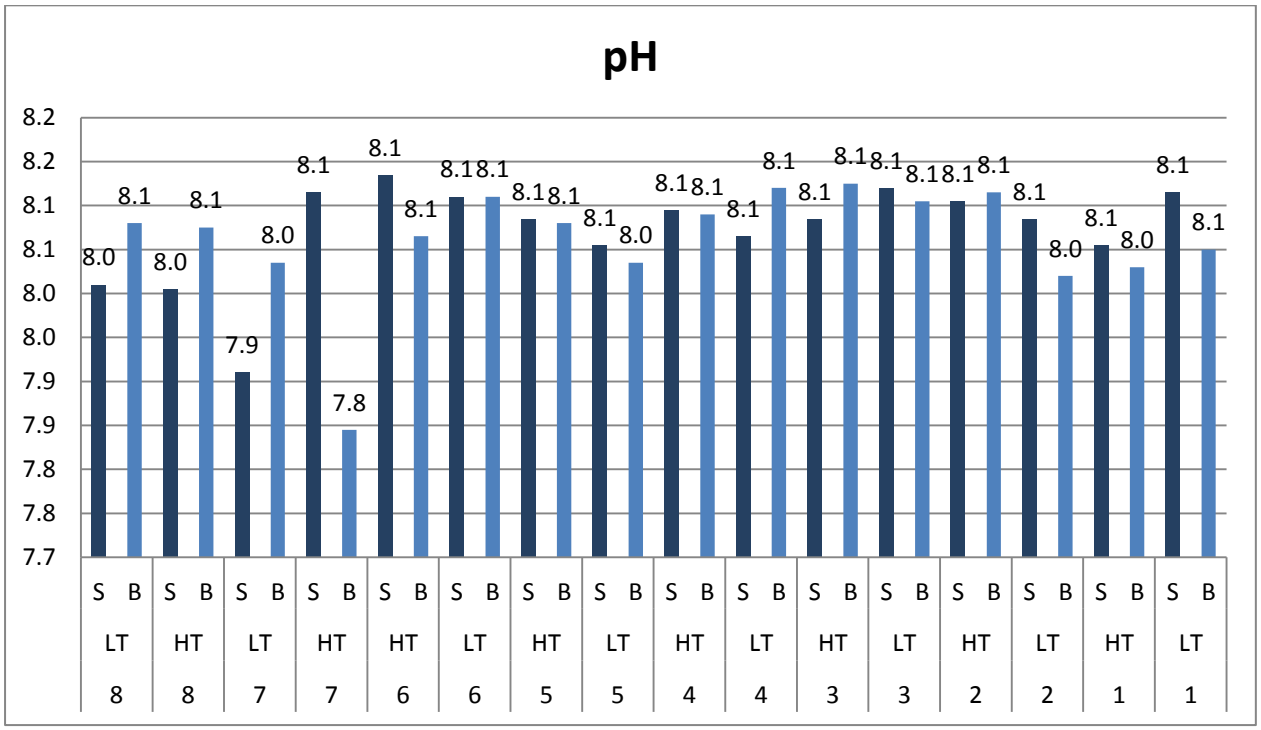


Figure 12.1. Comparative chart on measured pH at different stations

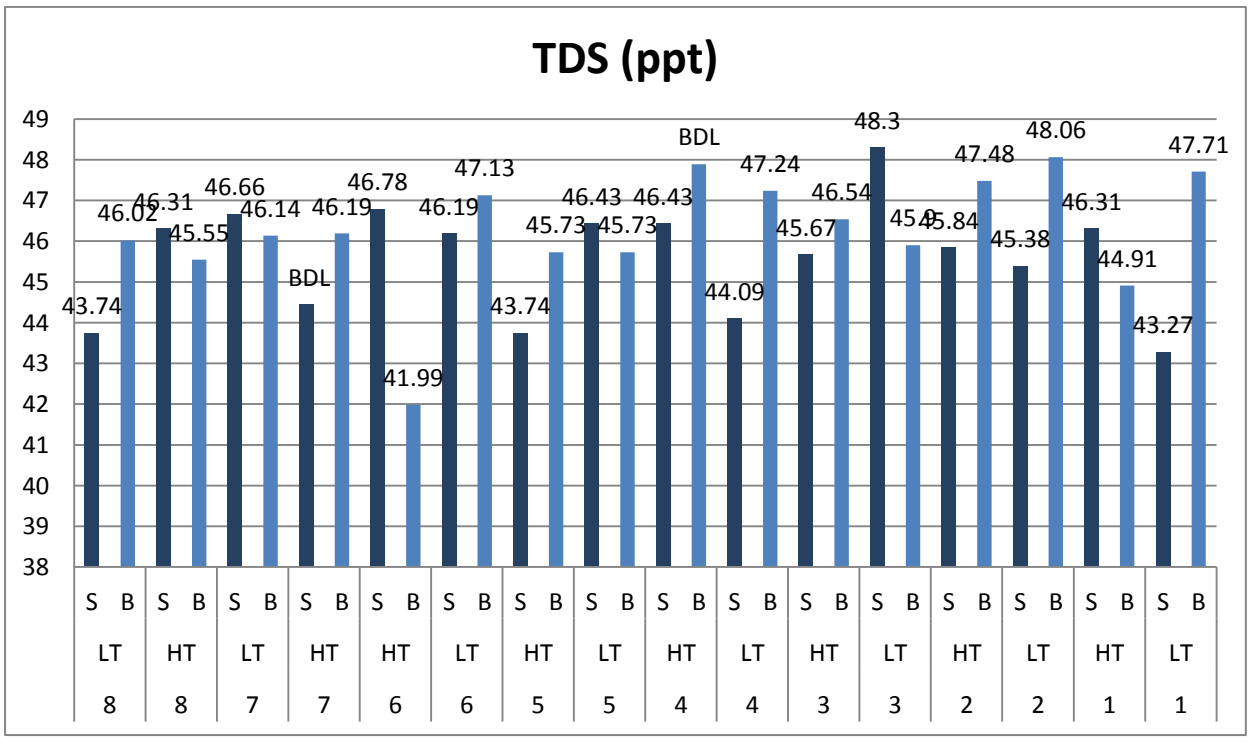


Figure 12.2. Comparative chart on measured TDS at different stations

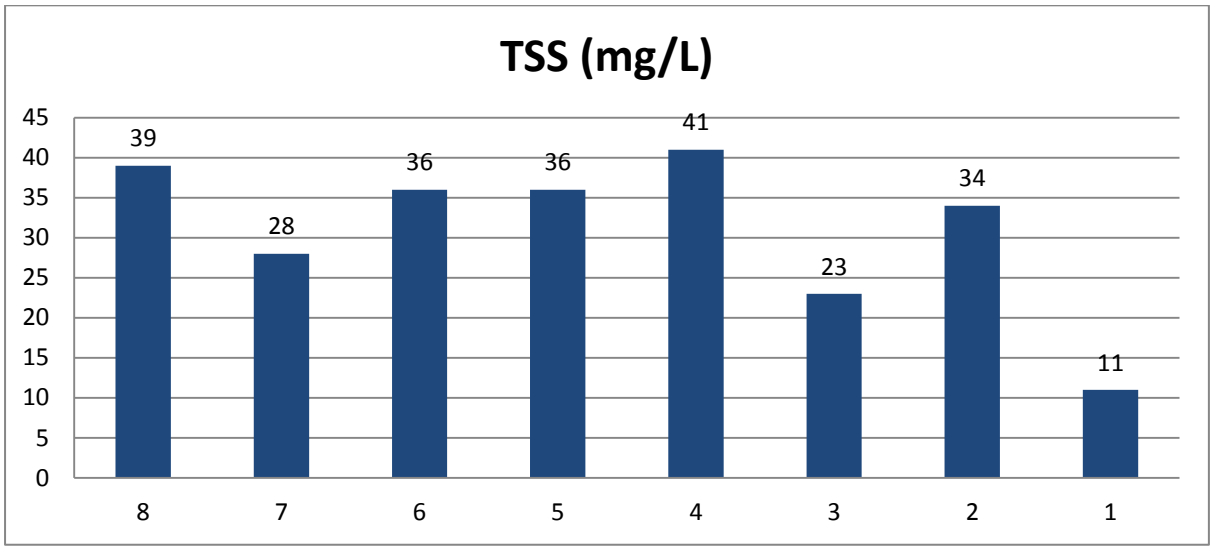


Figure 12.3. Comparative chart on measured TSS at different stations

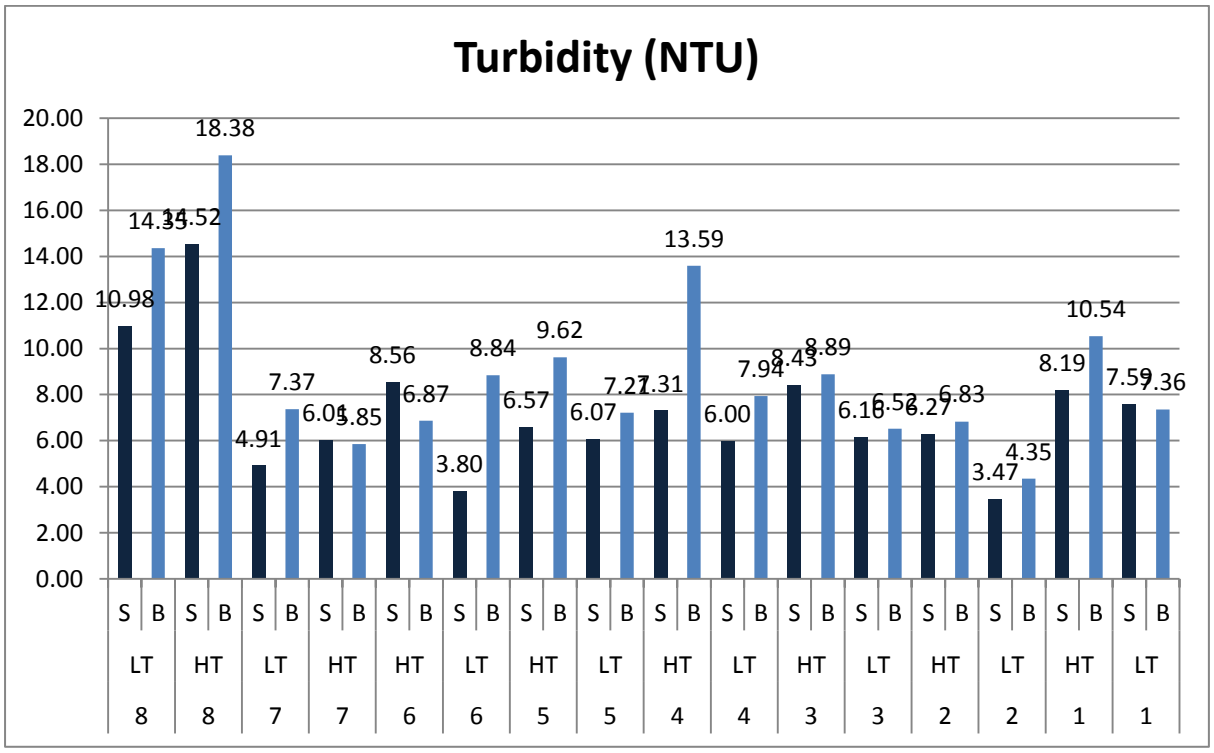


Figure 12.4. Comparative chart on measured turbidity at different stations

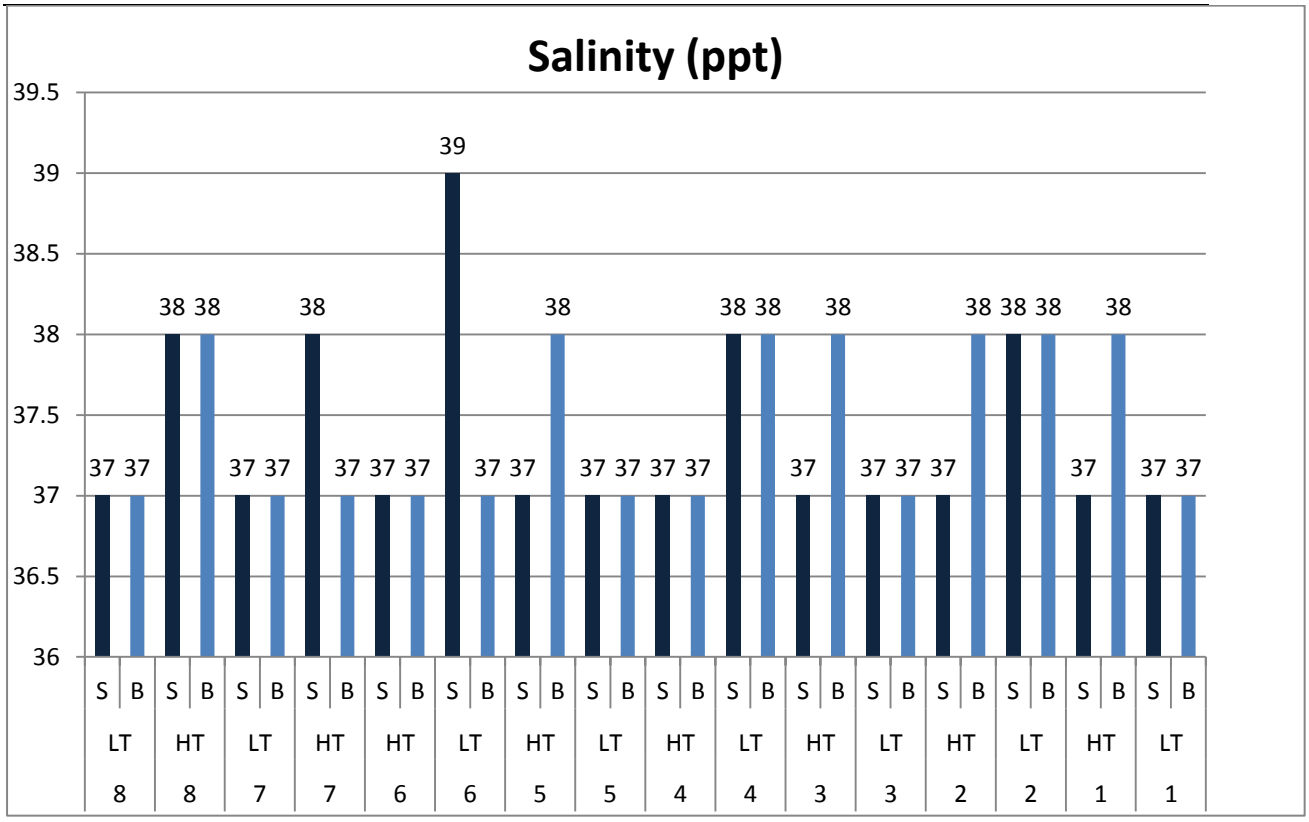


Figure 12.5. Comparative chart on measured salinity at different stations

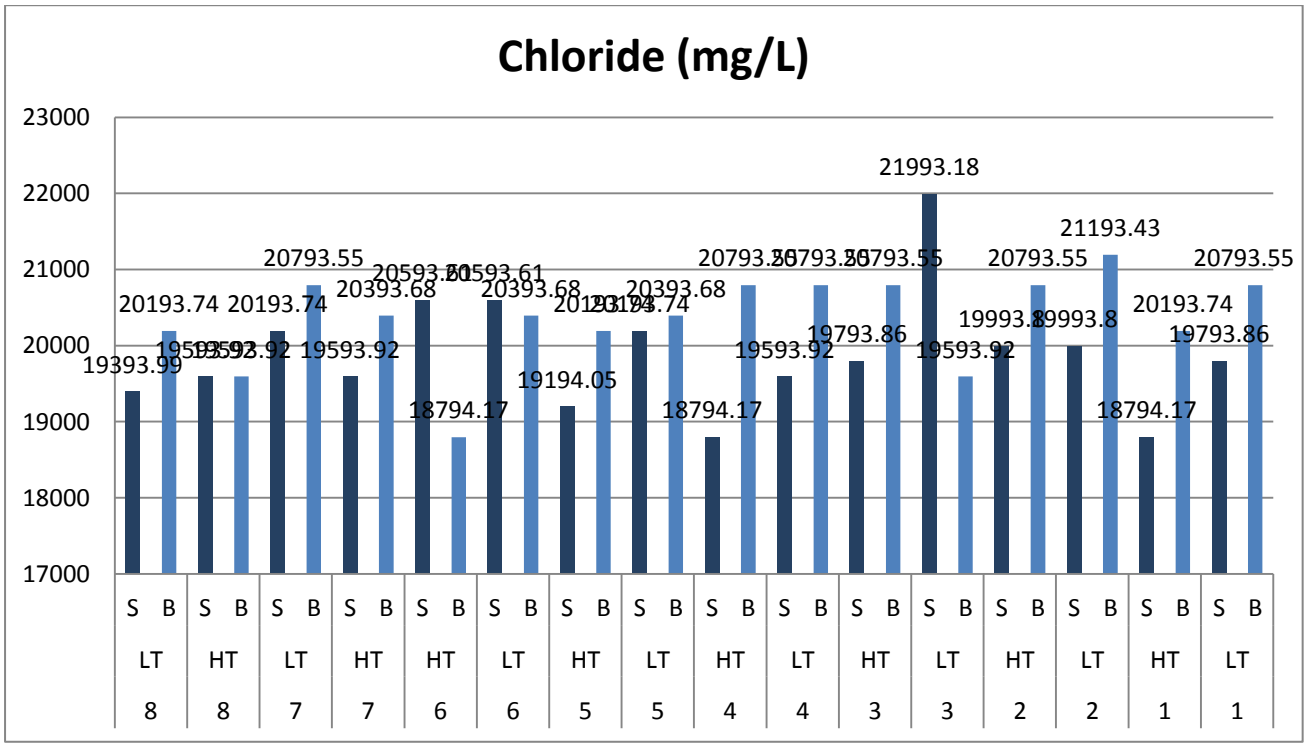


Figure 12.6. Comparative chart on measured chloride at different stations

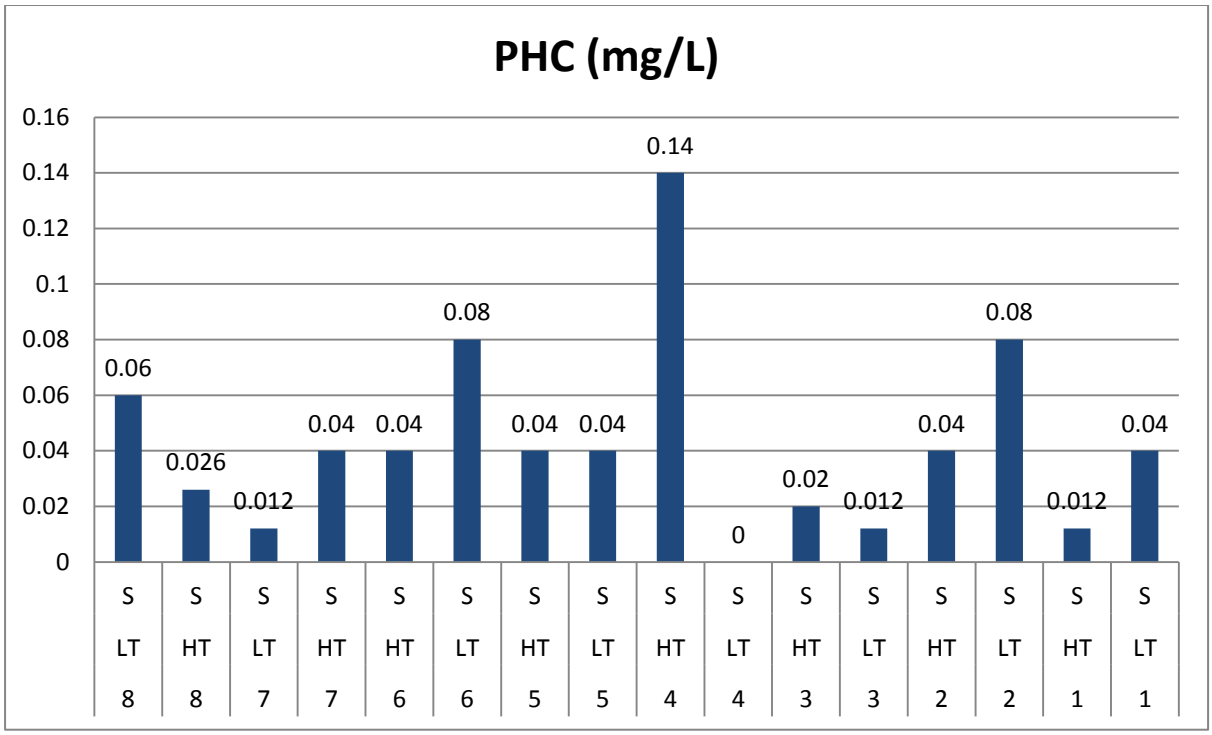


Figure 12.7. Comparative chart on measured PHC at different stations

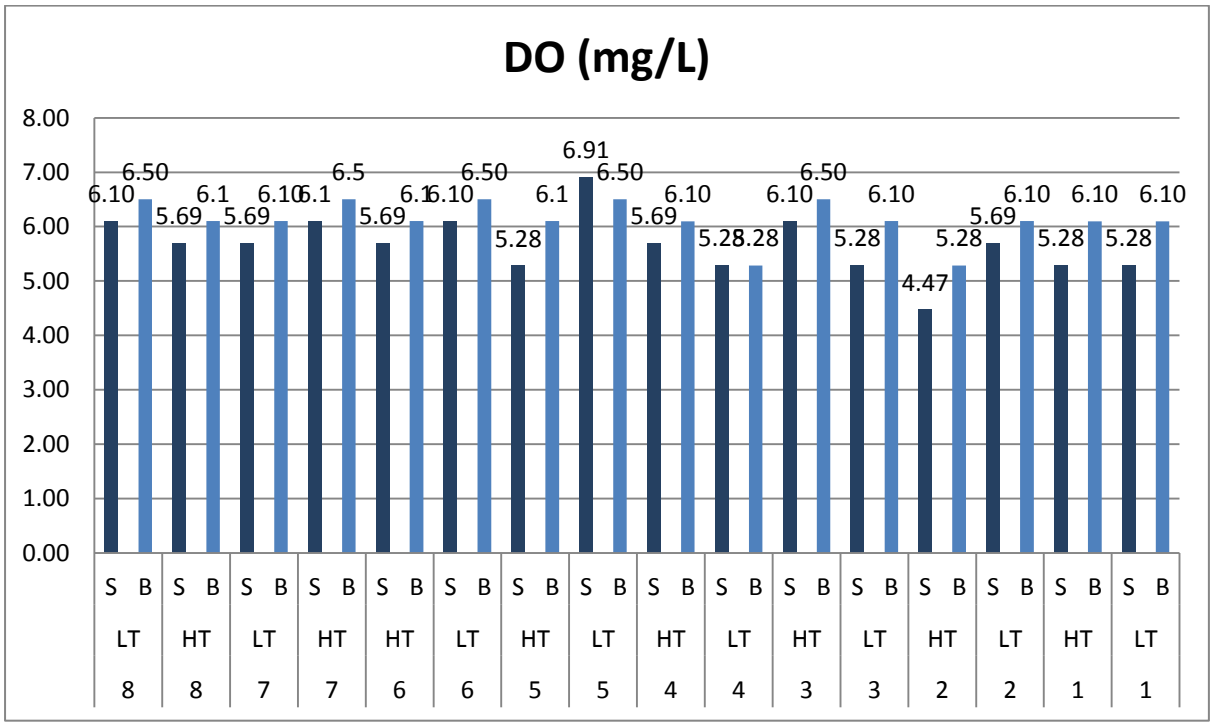


Figure 12.8. Comparative chart on measured DO level at different stations

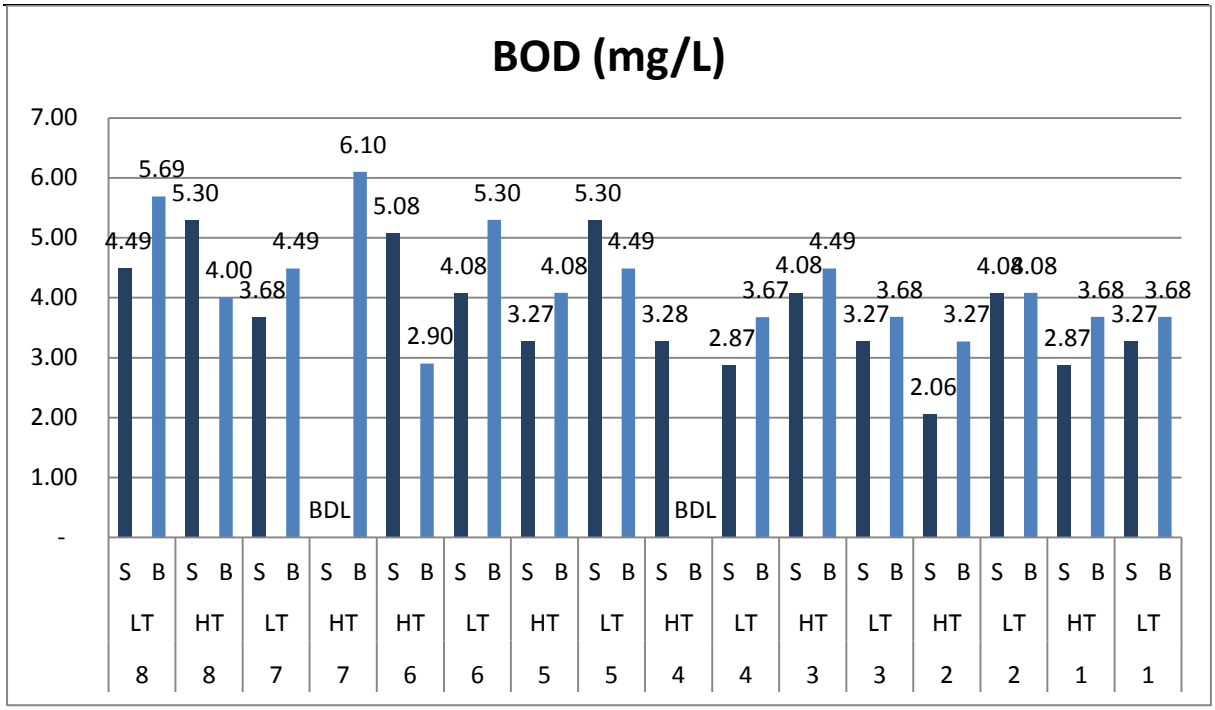


Figure 12.9. Comparative chart on measured BOD level at different stations

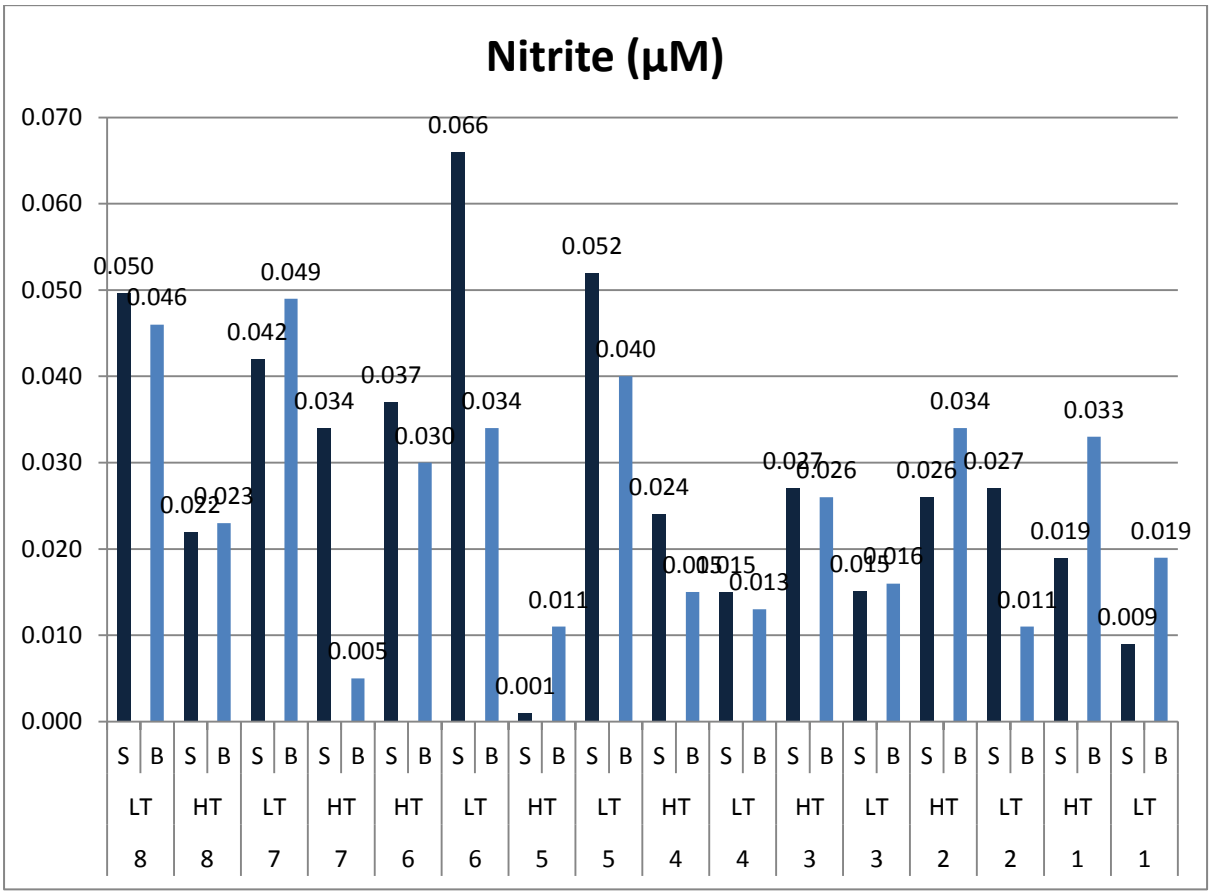


Figure 12.10. Comparative chart on measured nitrite at different stations

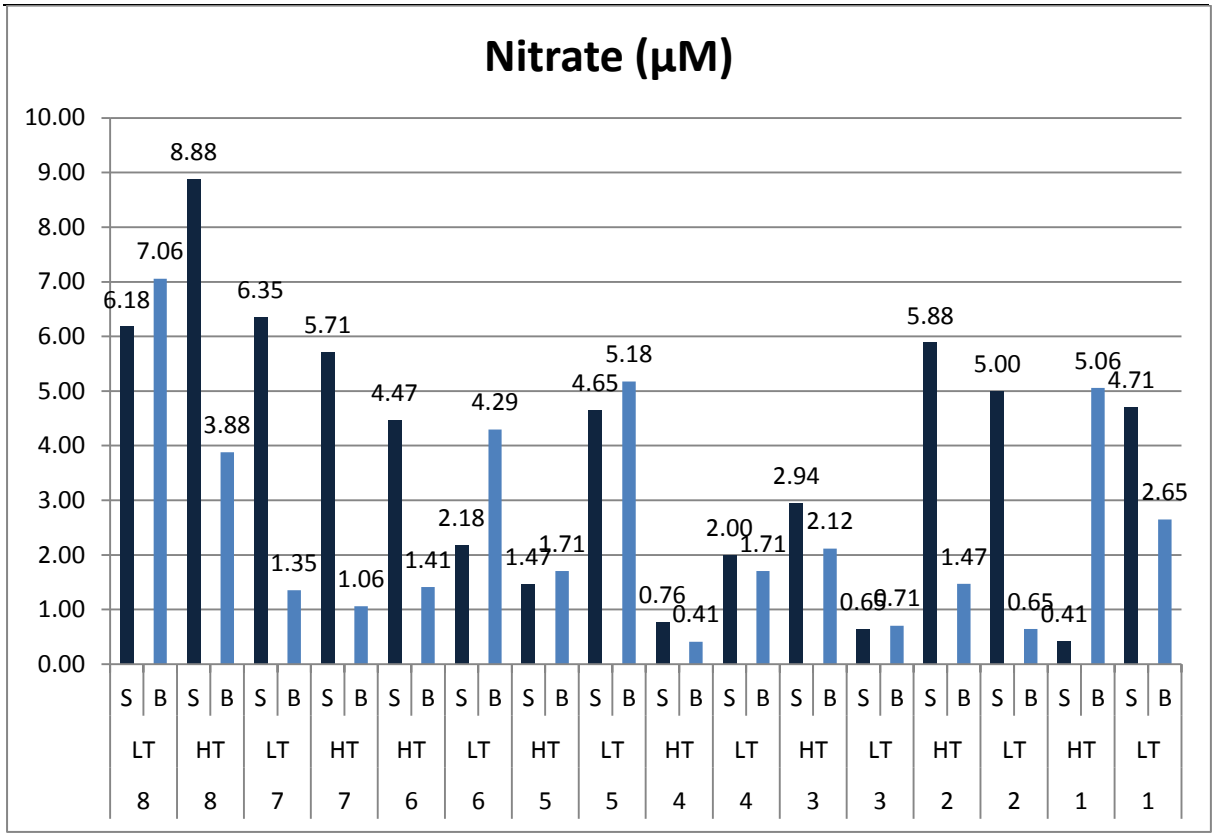


Figure 12.11. Comparative chart on measured nitrate at different stations

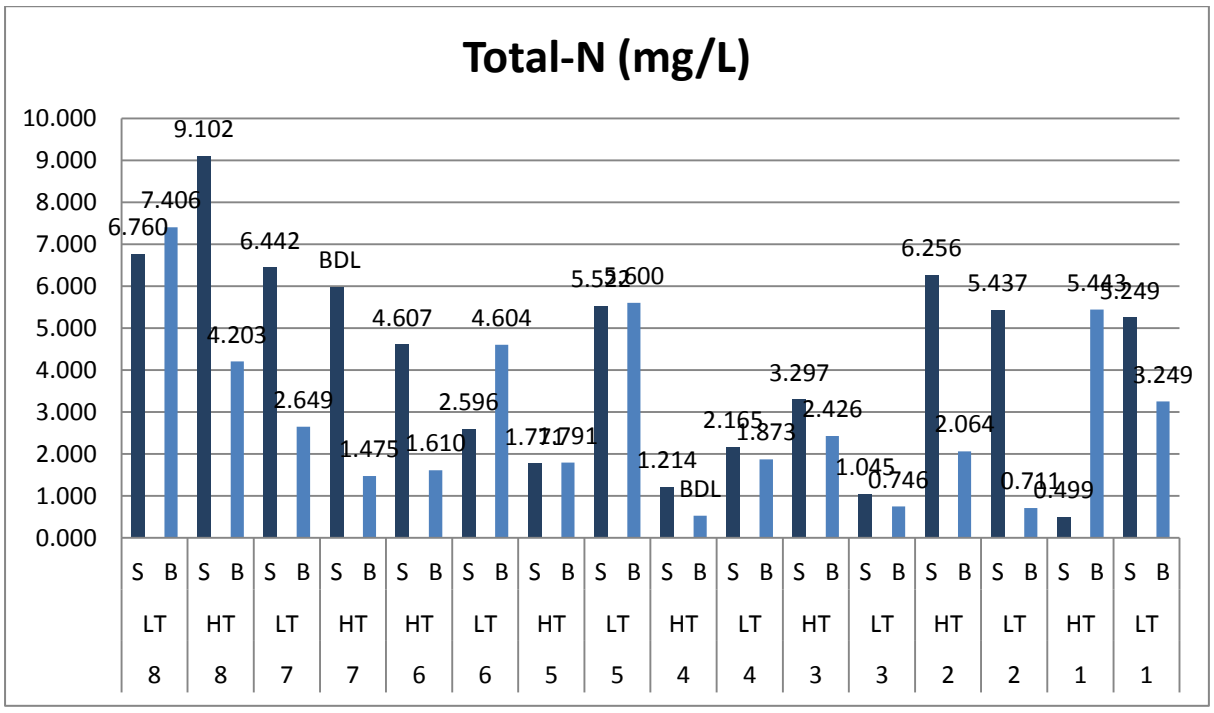


Figure 12.12. Comparative chart on measured total-N content at different stations

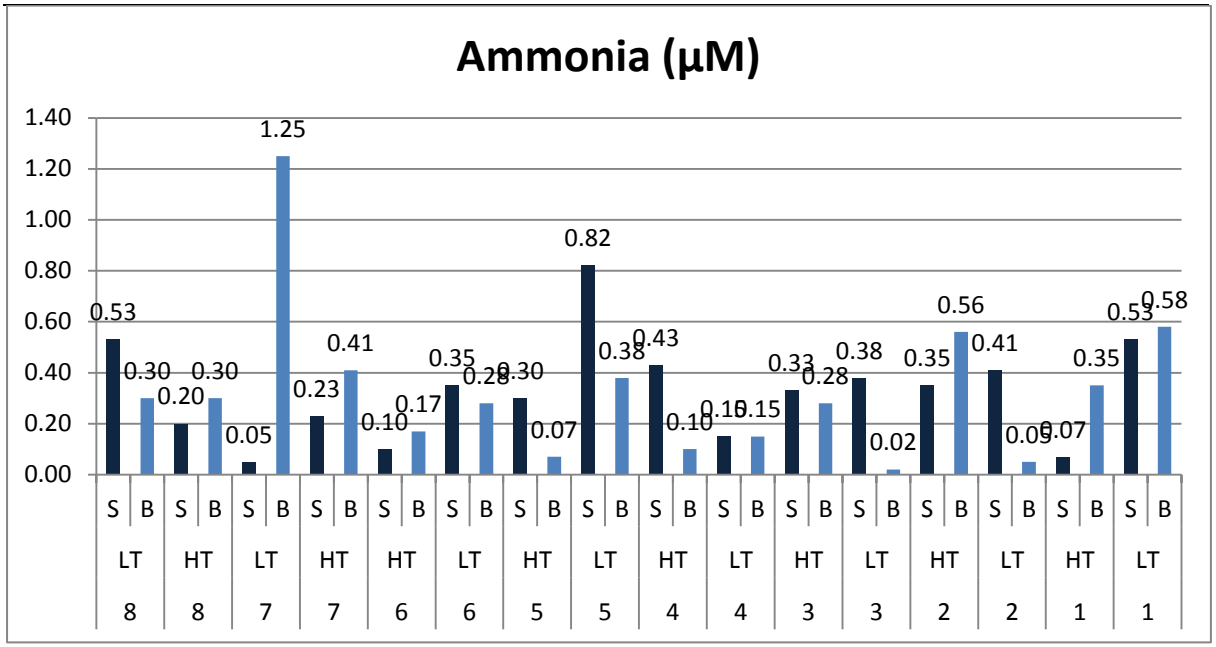


Figure 12.13. Comparative chart on measured ammonia at different stations

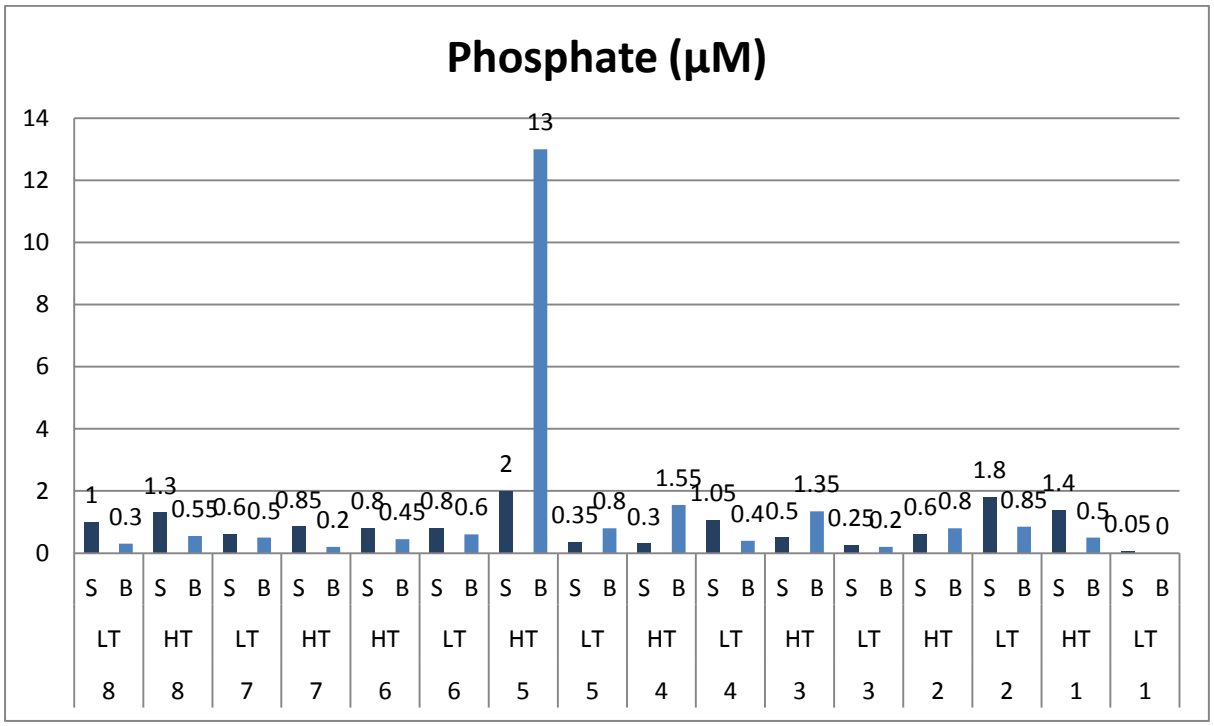


Figure 12.14. Comparative chart on measured phosphate at different stations

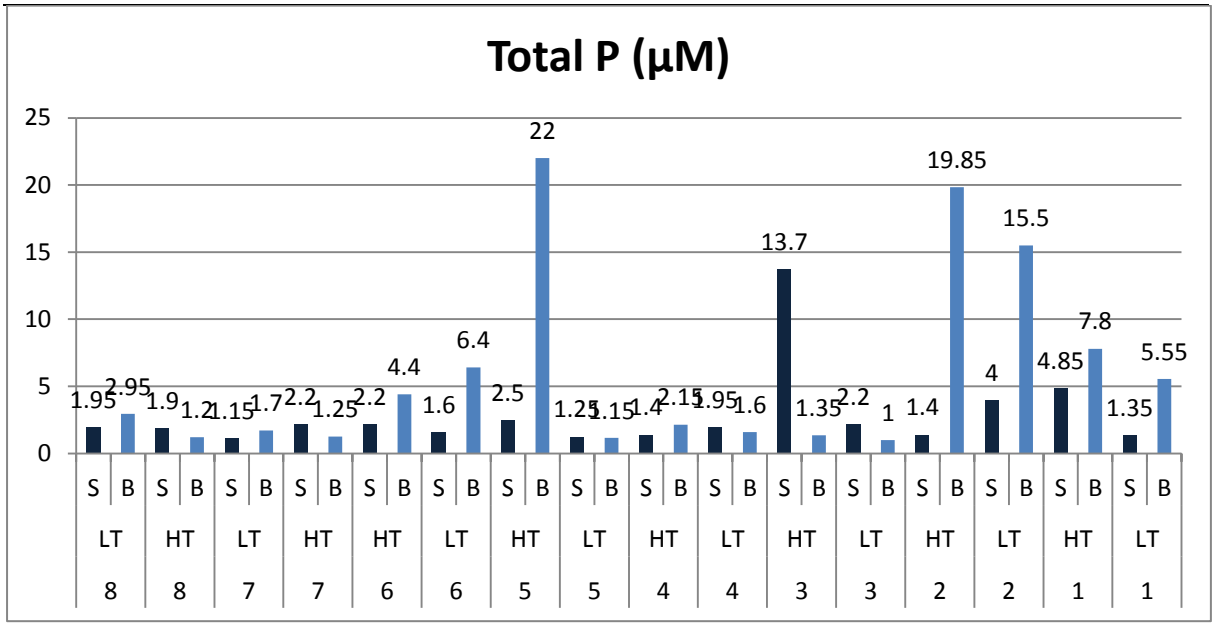


Figure 12.15. Comparative chart on measured total-phosphate content at different stations

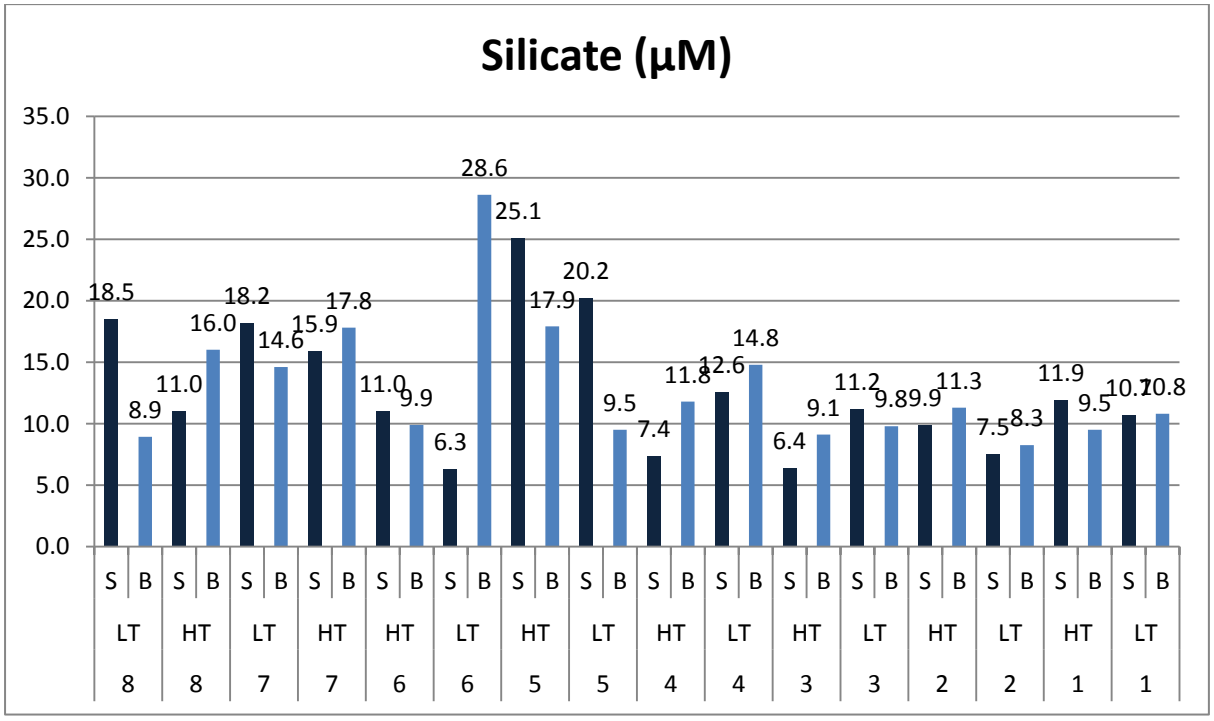


Figure 12.16. Comparative chart on measured silicate content at different stations

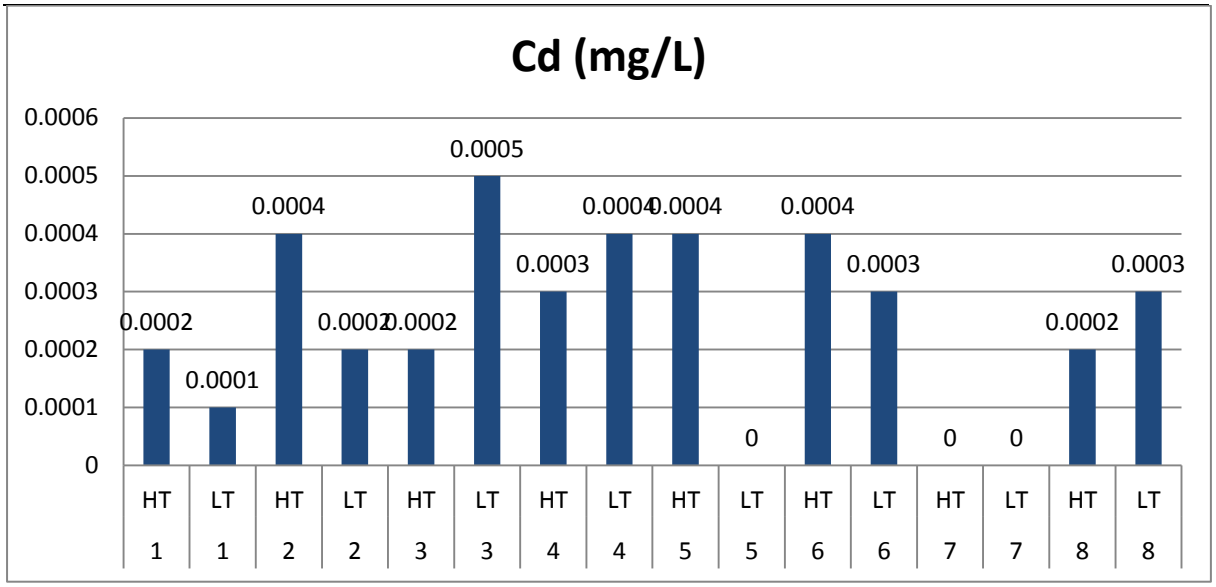


Figure 12.17. Comparative chart on measured Cd concentration at different stations

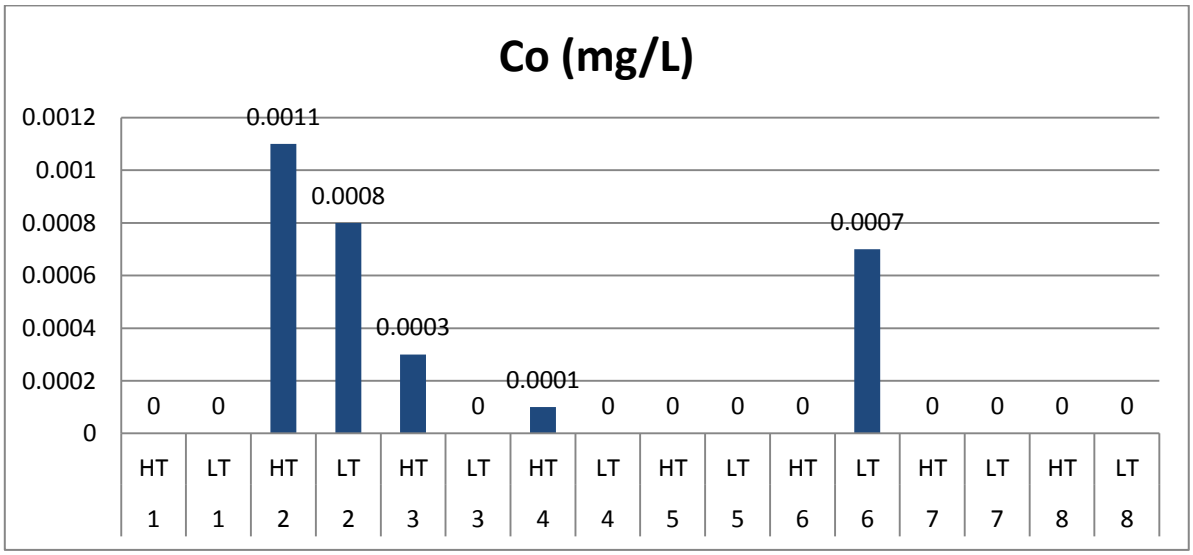


Figure 12.18. Comparative chart on measured Co concentration at different stations

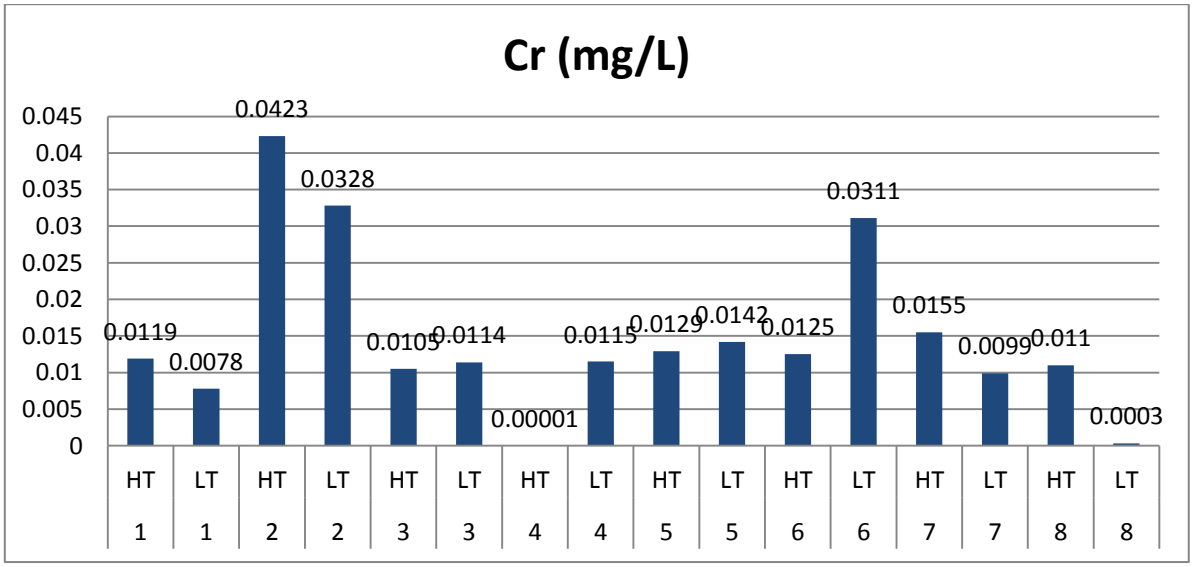


Figure 12.19. Comparative chart on measured Cr concentration at different stations

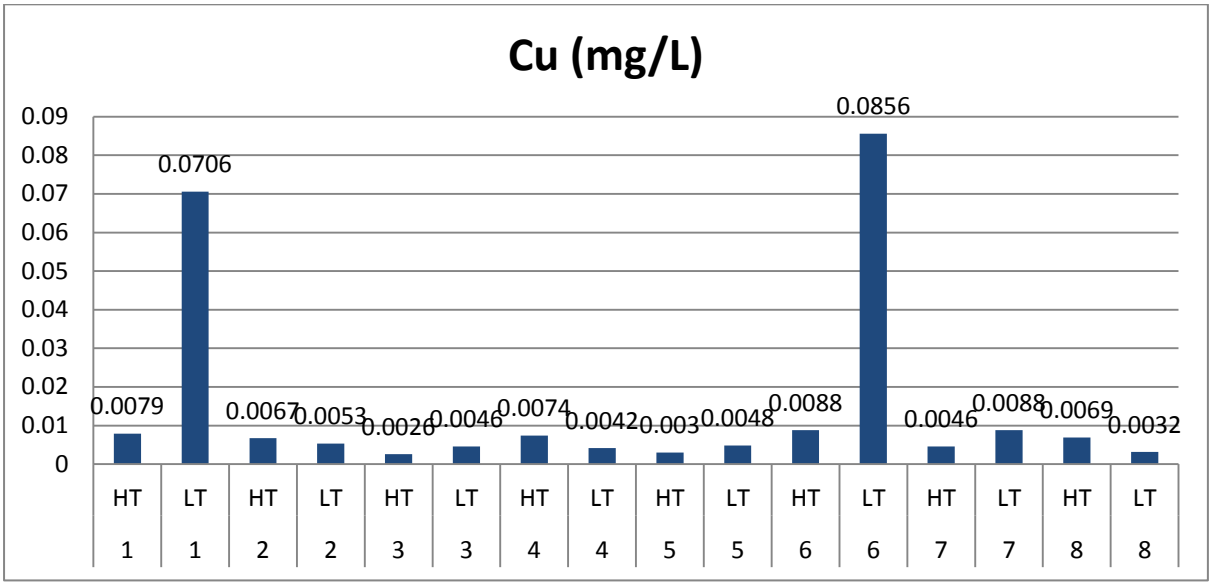


Figure 12.20. Comparative chart on measured Cu concentration at different stations

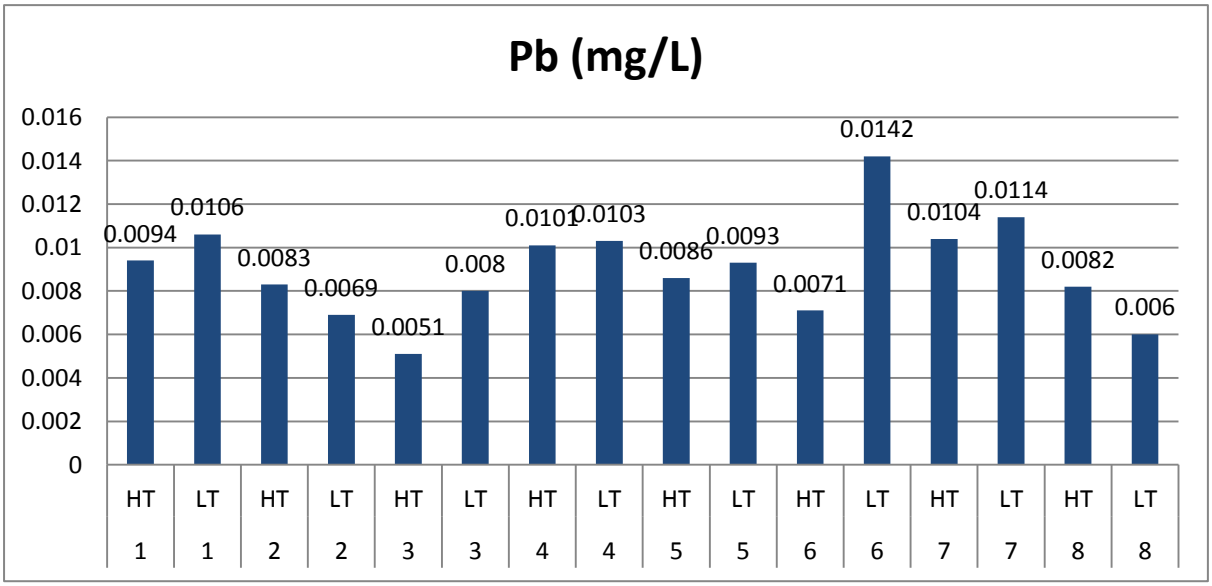


Figure 12.21. Comparative chart on measured Pb concentration at different stations

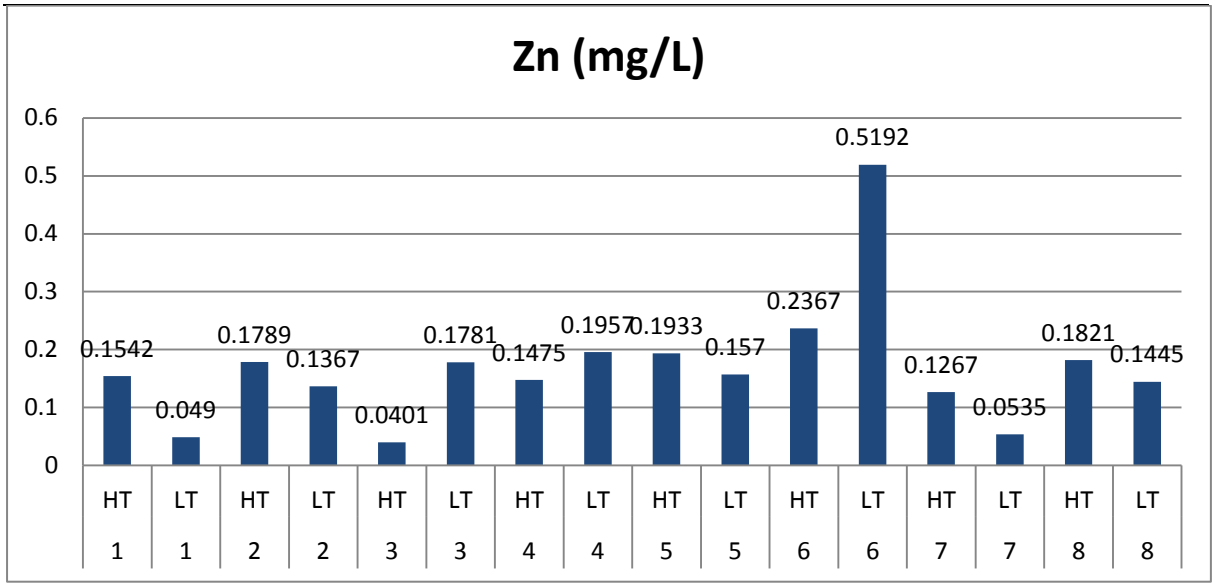
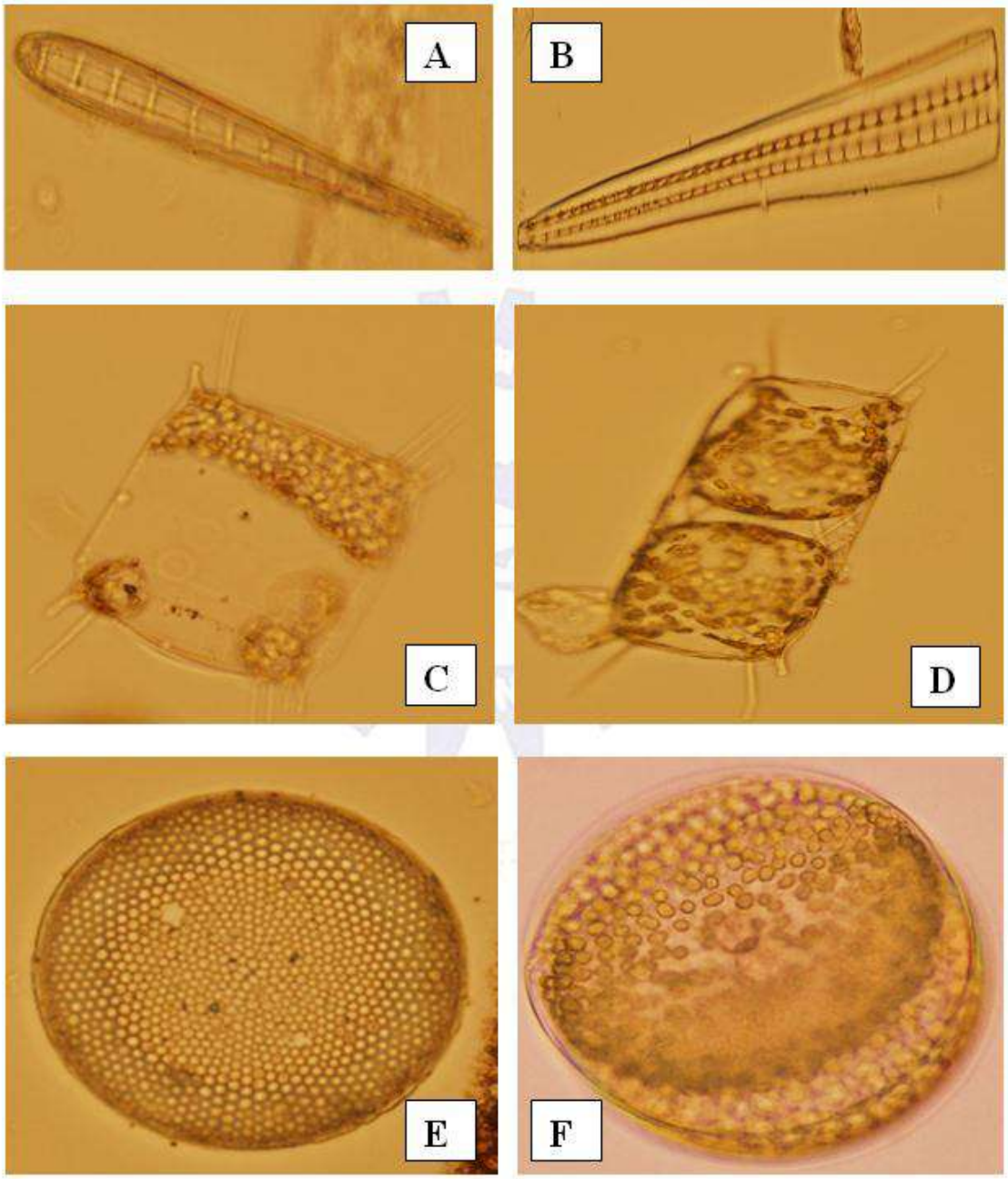
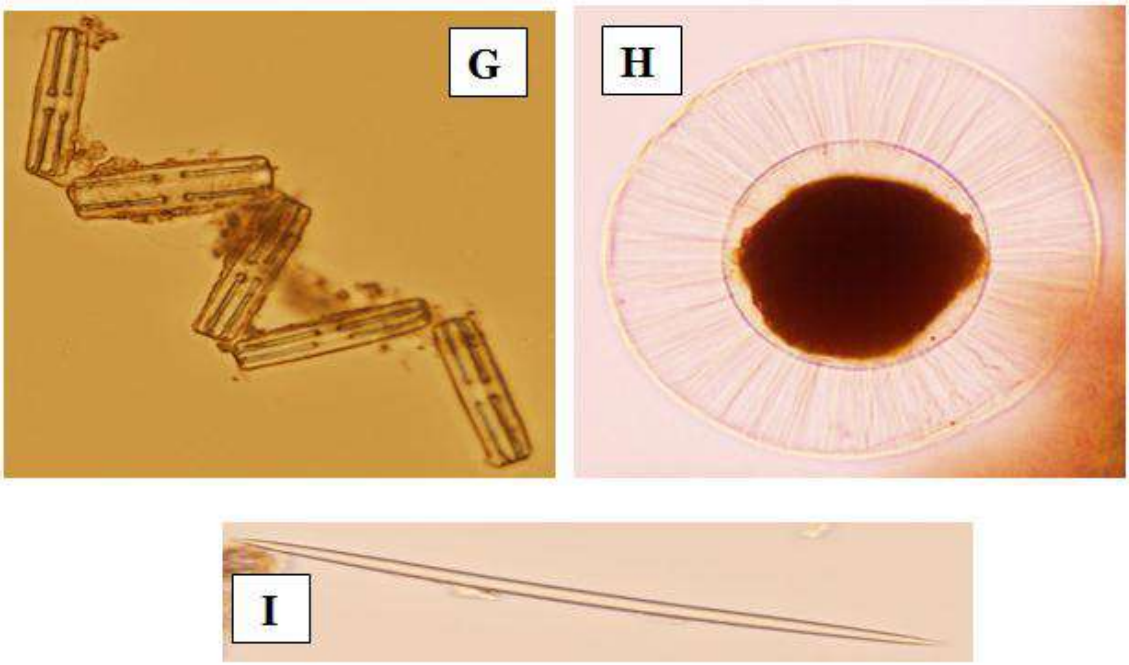


Figure 12.22. Comparative chart on measured Zn concentration at different stations

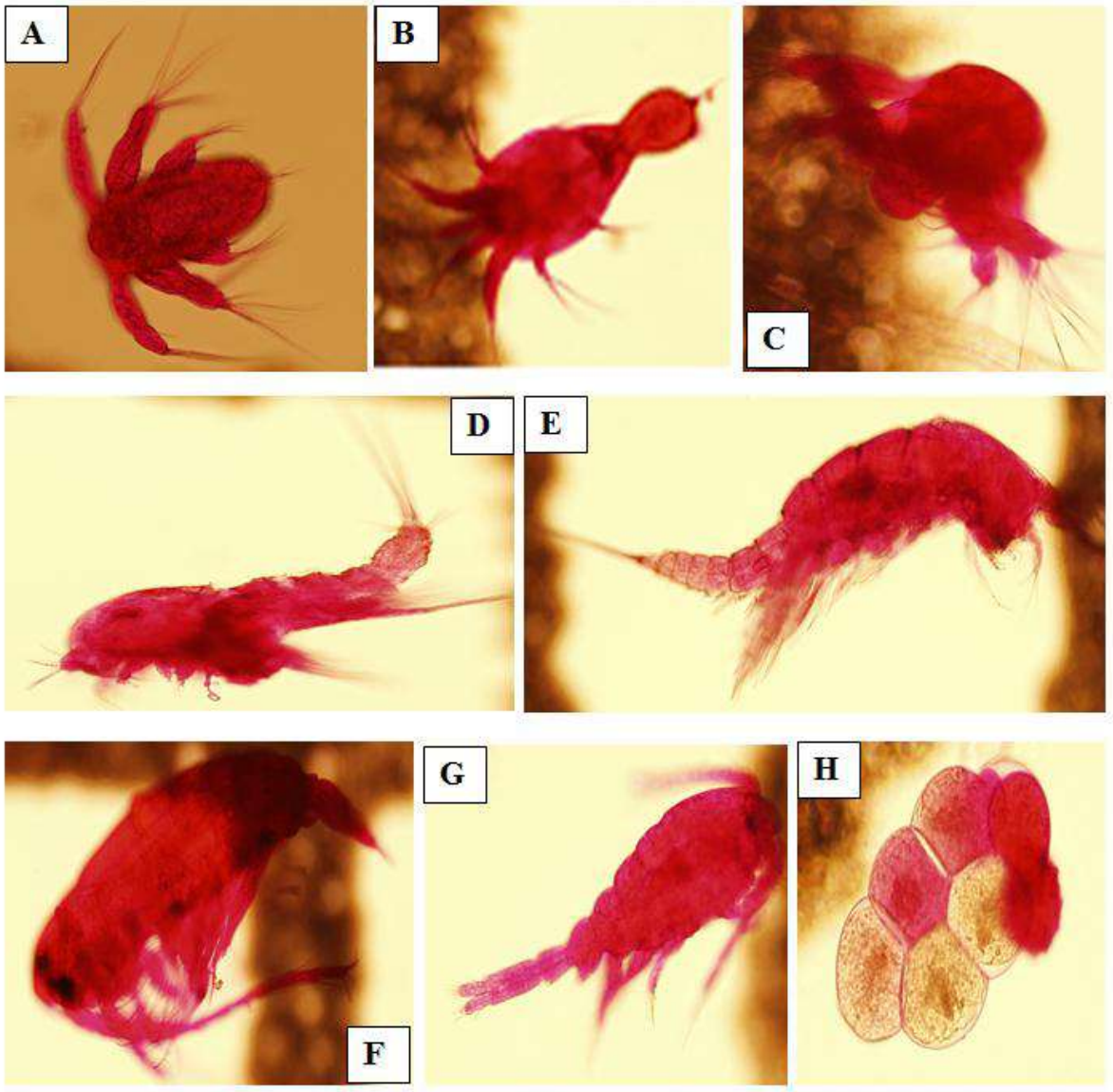


(A) *Climacosphenia* sp.-1 (B) *Climacosphenia* sp.-2 (C) *Biddulphia* sp.-1(D) *Biddulphia* sp.-2 (E) *Coscinodiscus*-1 (F) *Coscinodiscus*-2



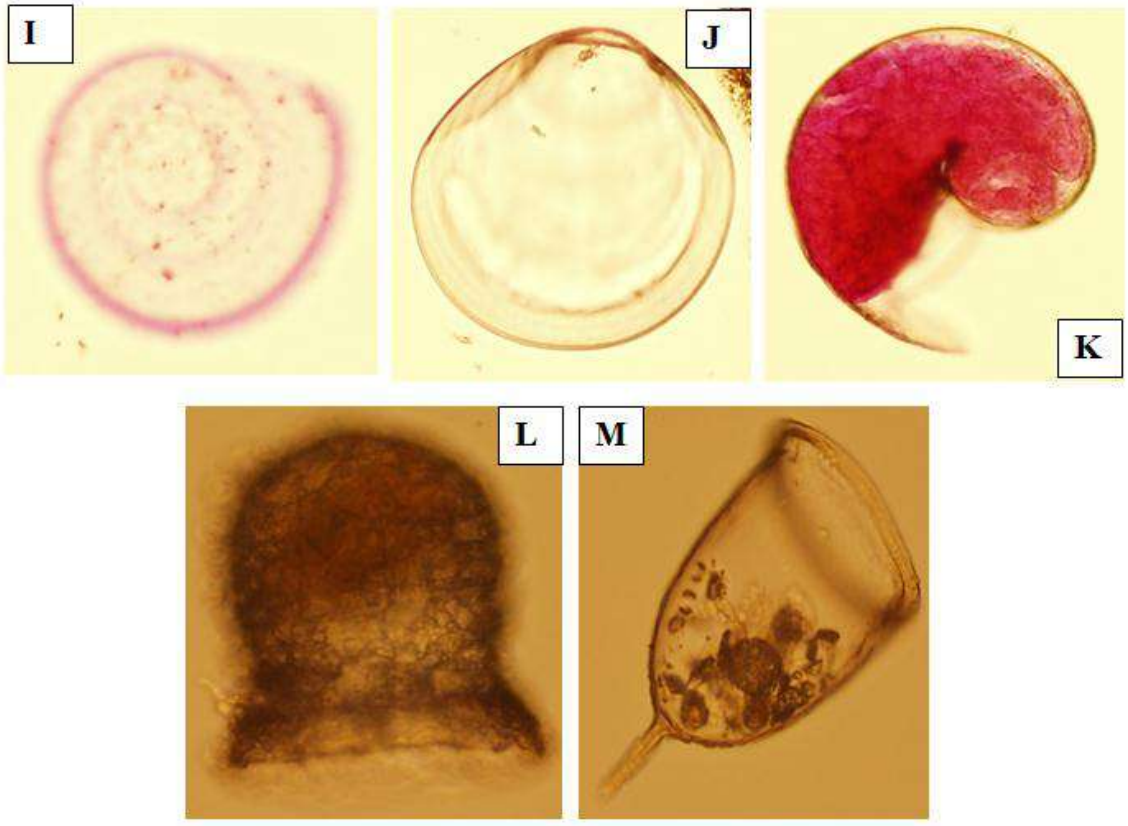
(G) *Grammatophora* sp. (H) *Planktoniella* (I) *Synedra*

Figure 12.23. Plates showing the identified phytoplanktons



(A) *Nauplius larvae*-1 (B) *Nauplius larvae*-2 (C) *Nauplius larvae*-3 (D) *Herpacticoida*-1

(E) *Herpacticoida*-2 (F) *Calanoida* (G) *Cyclopoida* (H) Egg



(I)*Gastropod larvae*-1 (J) *Gastropod larvae*-2 (K) *Veliger larvae*
(L) *Tintinnid*-1 (M) *Tintinnid*-2

Figure 12.24. Plates showing the identified zooplanktons

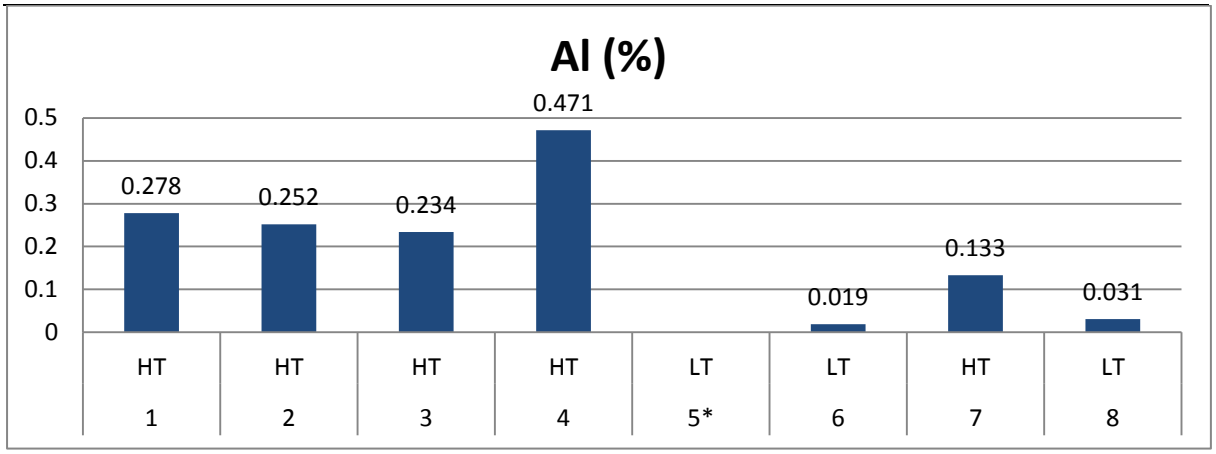


Figure 12.25. Comparative chart on measured Al content in sediments at different stations

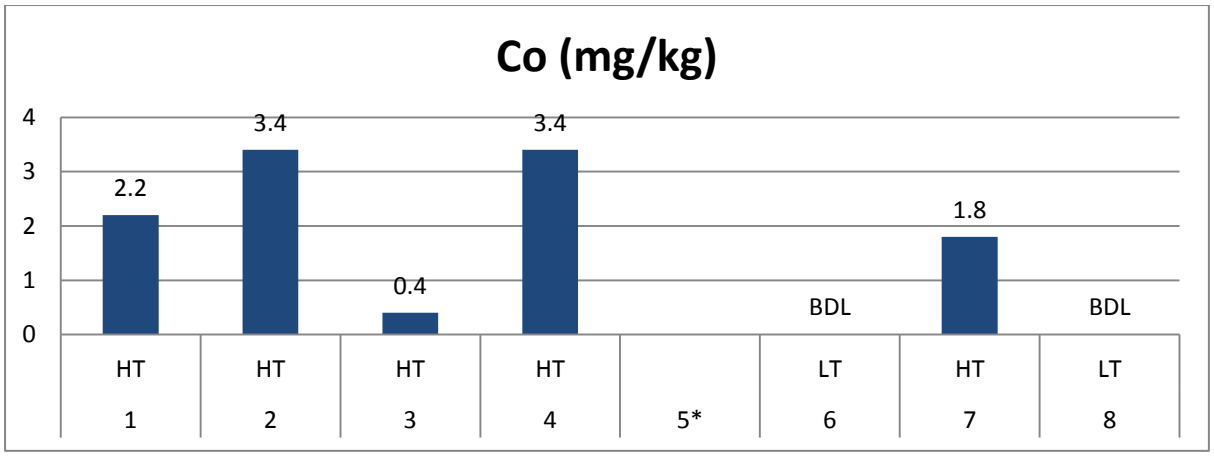


Figure 12.26. Comparative charts on measured Co content in sediments at different stations

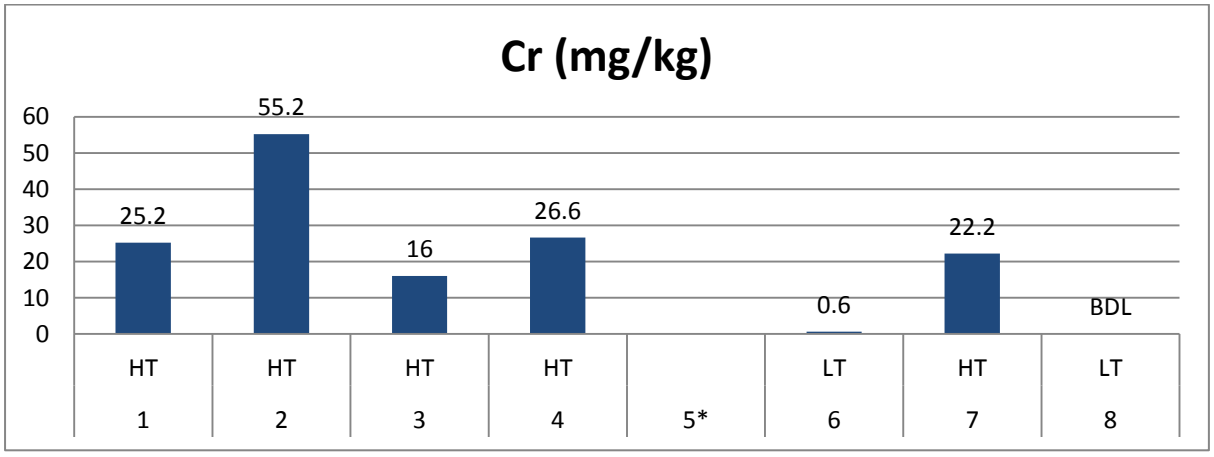


Figure 12.27. Comparative chart on measured Cr content in sediments at different stations

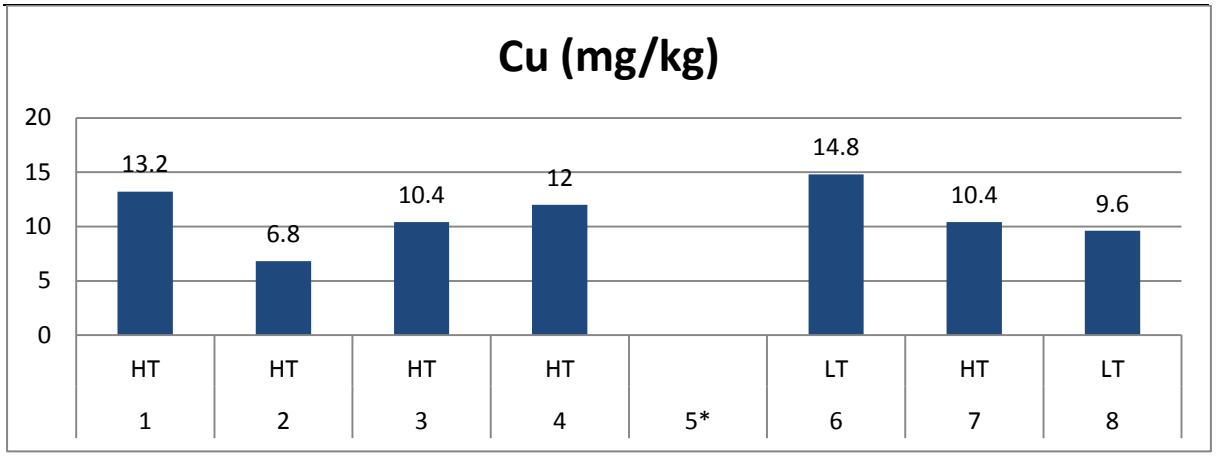


Figure 12.28. Comparative chart on measured Cu content in sediments at different stations

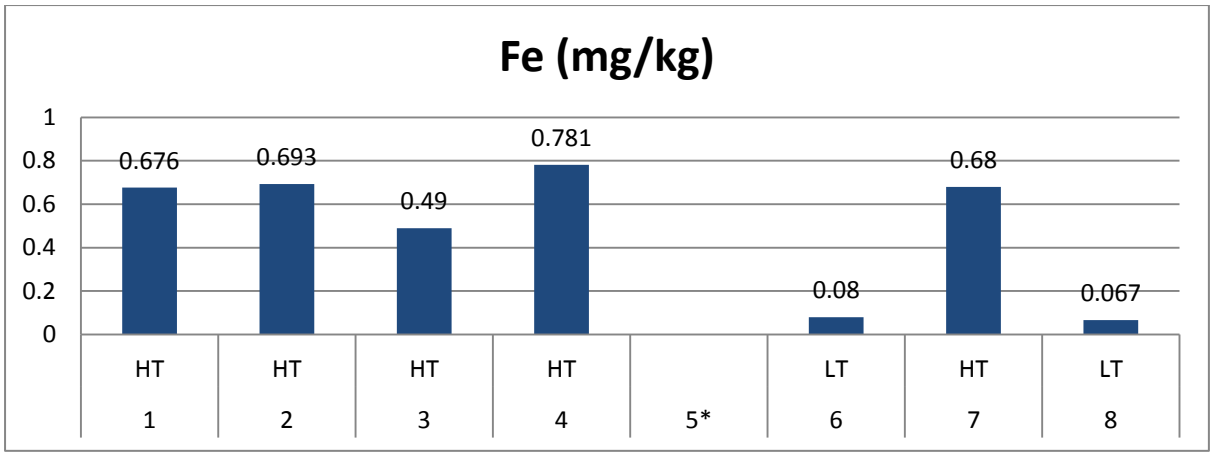


Figure 12.29. Comparative chart on measured Fe content in sediments at different stations

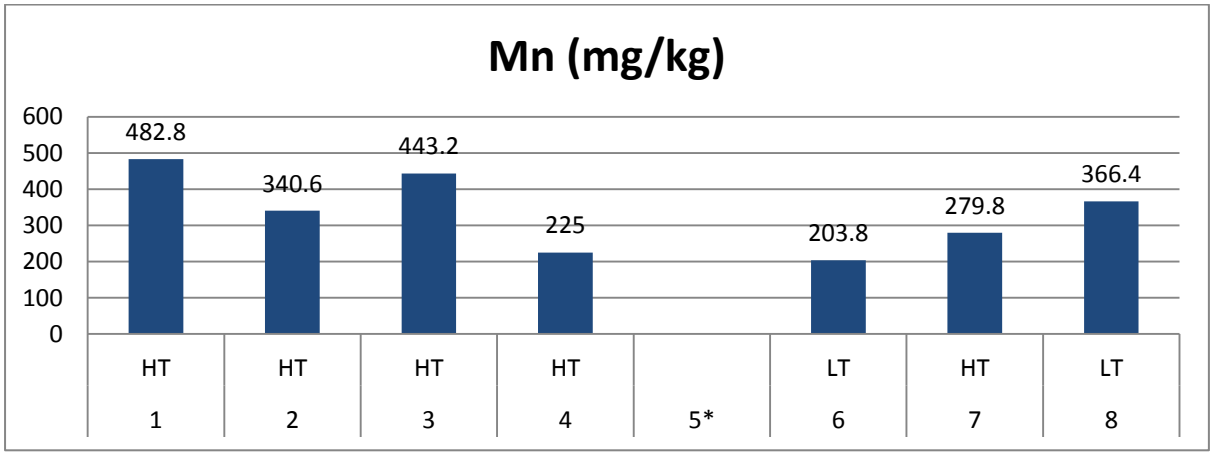


Figure 12.30. Comparative chart on measured Mn content in sediments at different stations

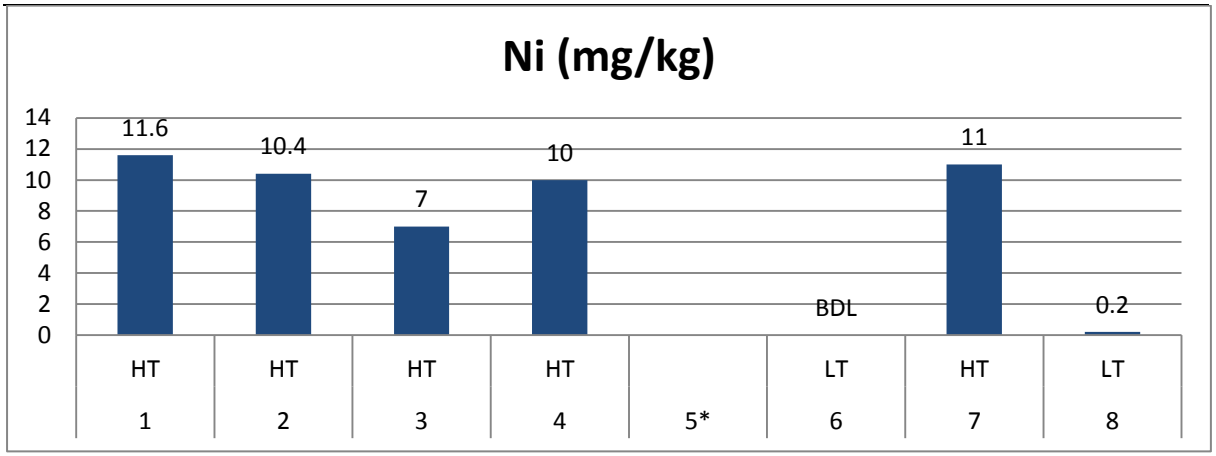


Figure 12.31. Comparative chart on measured Ni content in sediments at different stations

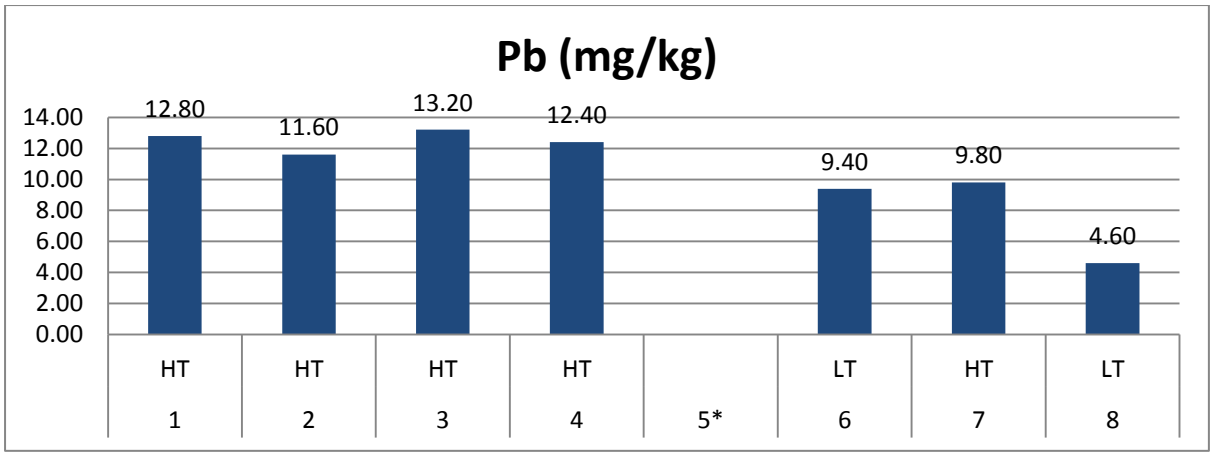


Figure 12.32. Comparative chart on measured Pb content in sediments at different stations

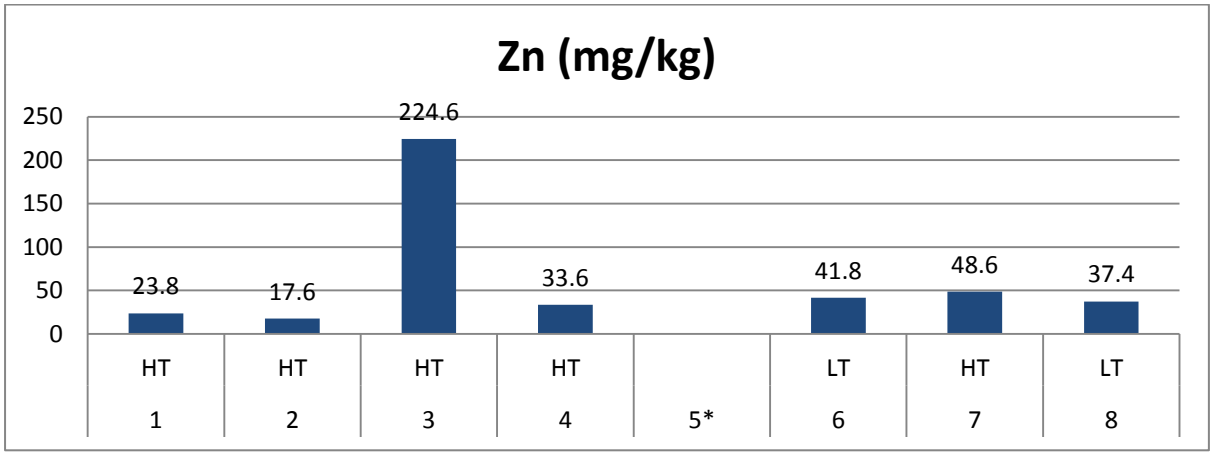
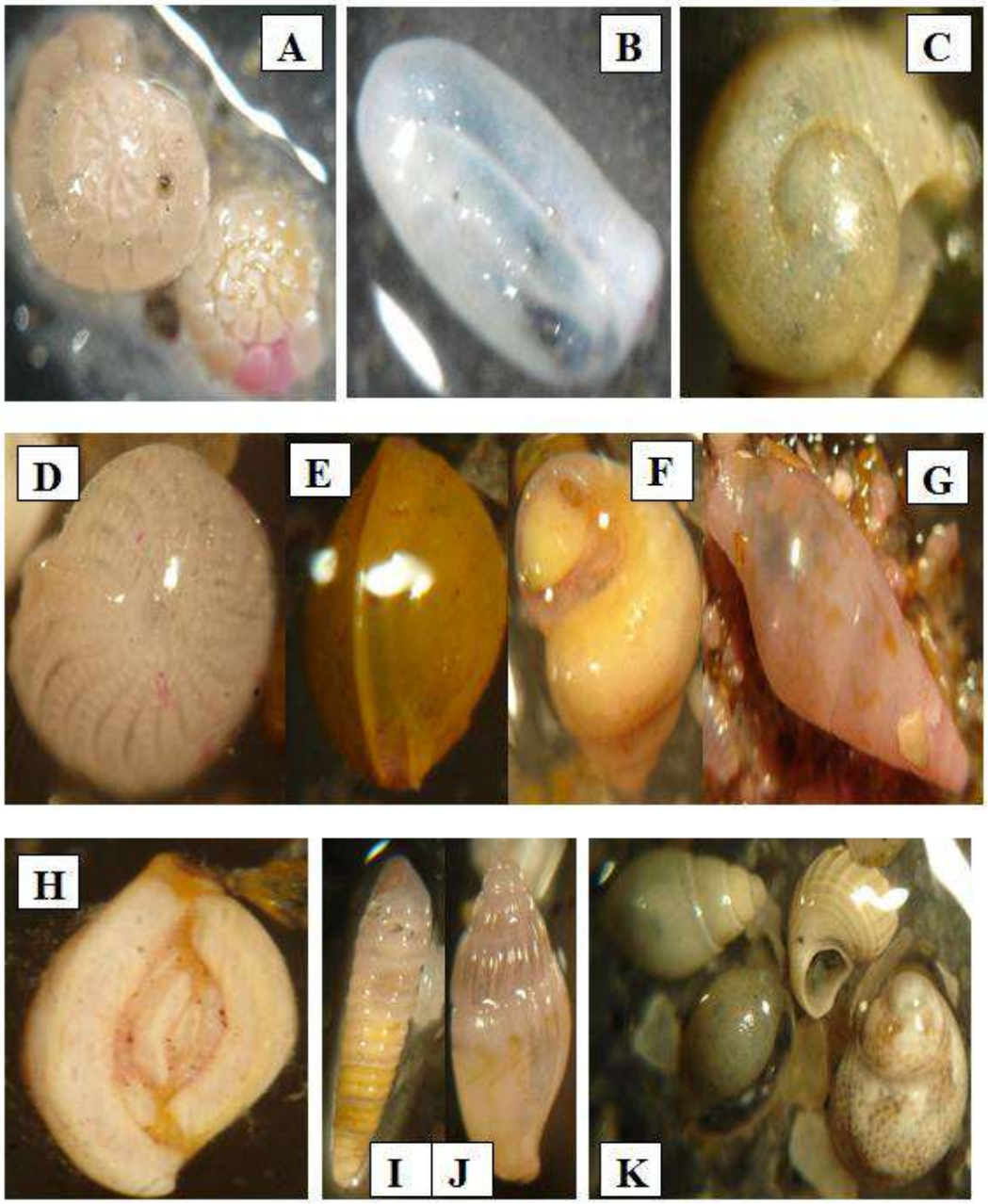
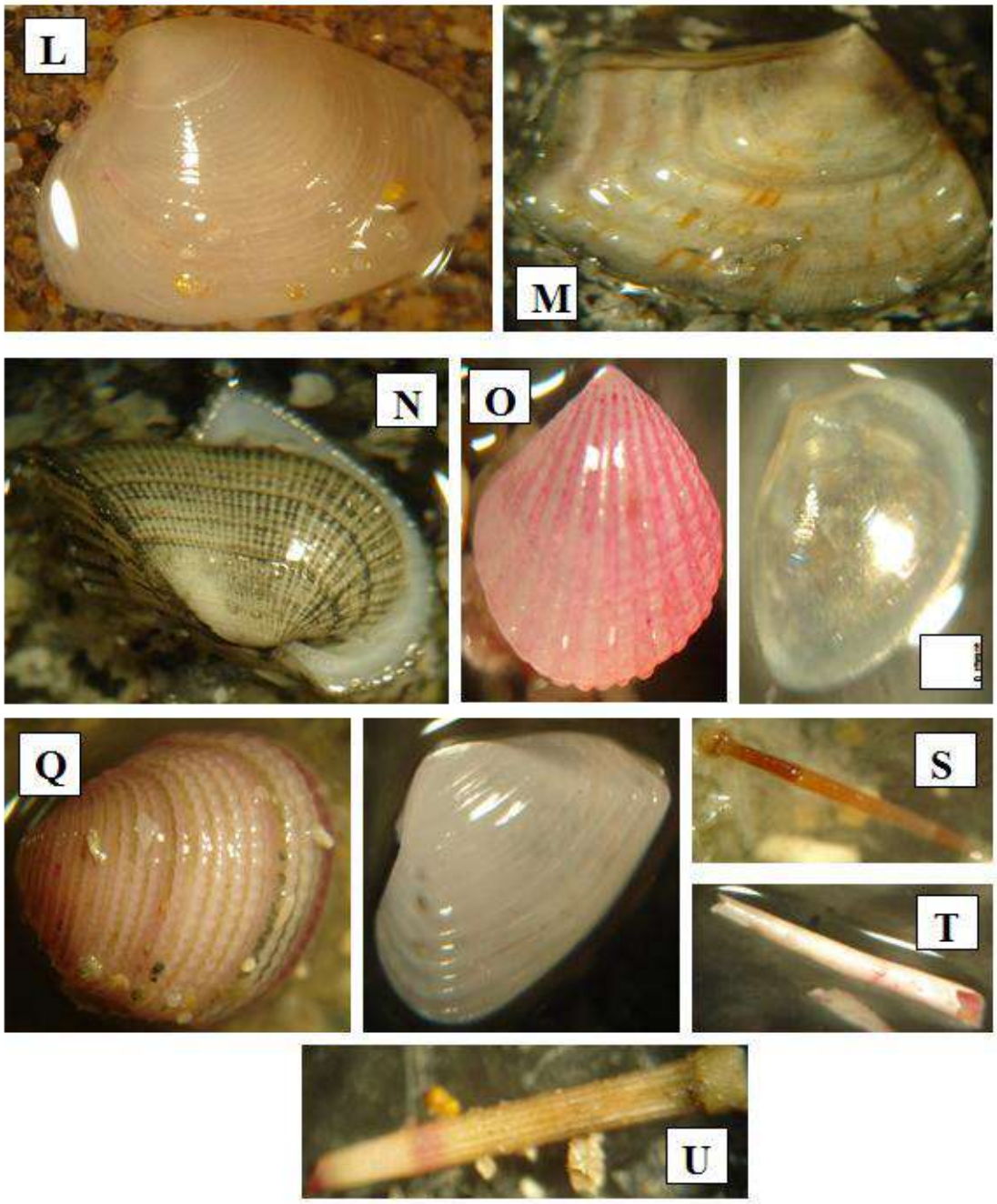


Figure 12.33. Comparative chart on measured Zn content in sediments at different stations

***Sediment was not collected at Station No. 5 because of the rocky bottom.**



(A) *Gastropoda* sp.-1 (B) *Gastropoda* sp.-2 (C) *Gastropoda* sp.-3 (D) *Gastropoda* sp.-4
(E) *Gastropoda* sp.-5 (F) *Gastropoda* sp.-6 (G) *Gastropoda* sp.-7 (H) *Gastropoda* sp.-8
(I) *Gastropoda* sp.-9 (J) *Gastropoda* sp.-10 (K) *Gastropoda* sp.-11



(L) *Bivalvia* sp.-1 (M) *Bivalvia* sp.-2 (N) *Bivalvia* sp.-3 (O) *Bivalvia* sp.-4 (P) *Bivalvia* sp.-5

(Q) *Bivalvia* sp.-6 (R) *Bivalvia* sp.-7 (S) *Dentalium* sp.-1 (T) *Dentalium* sp.-2 (U) *Dentalium* sp.-3

Figure 12.34. Plates showing the identified benthic organism

Figure 12.35. Different algal species belonging to Chlorophyceae

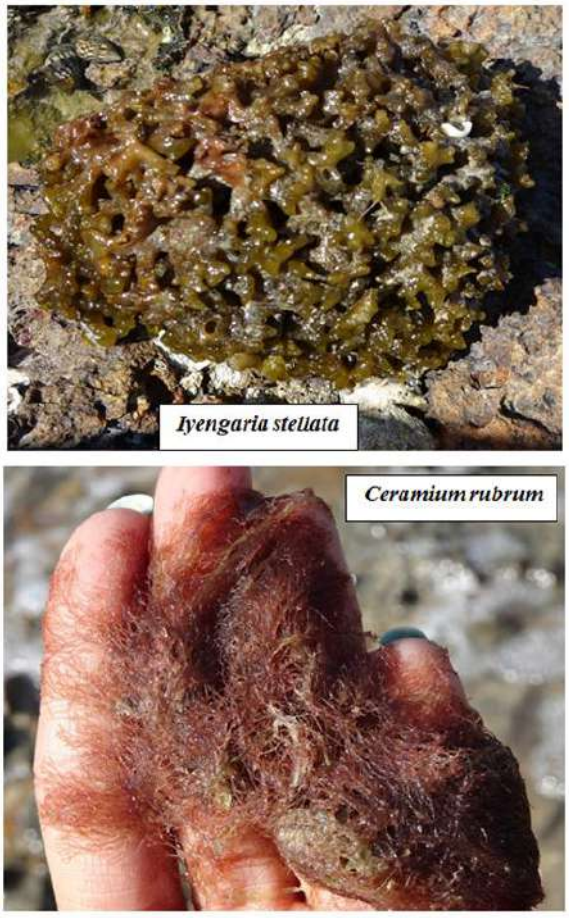


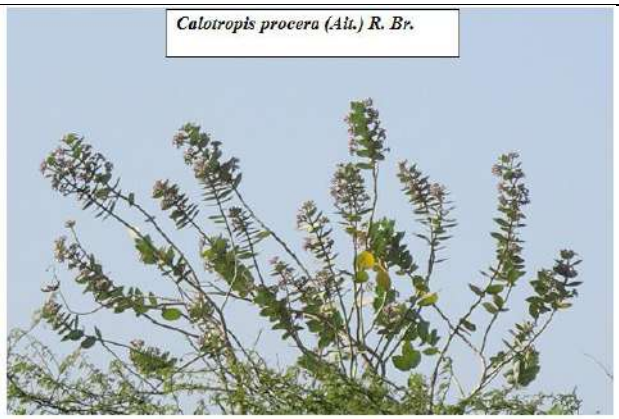
Figure 12.36. Different algal species belonging to Phaeophyceae and Rhodophyceae

Plover sp.

Grey heron

Greater egret

Figure 12.37. Birds found at the study area


Calotropis procera (Ait.) R. Br.

Capparis decidua (Forsk.) Edgew

Euphorbia neriifolia L.

Salvodora persica L.

Figure 12.38. Plants observed during survey

Figure 12.39. Macro benthos observed in the study area

Figure 12.40. Molluscs observed in the study area

Figure 12.41. *Avicennia marina* in the intertidal area

Figure 12.42. Corals observed in the study area

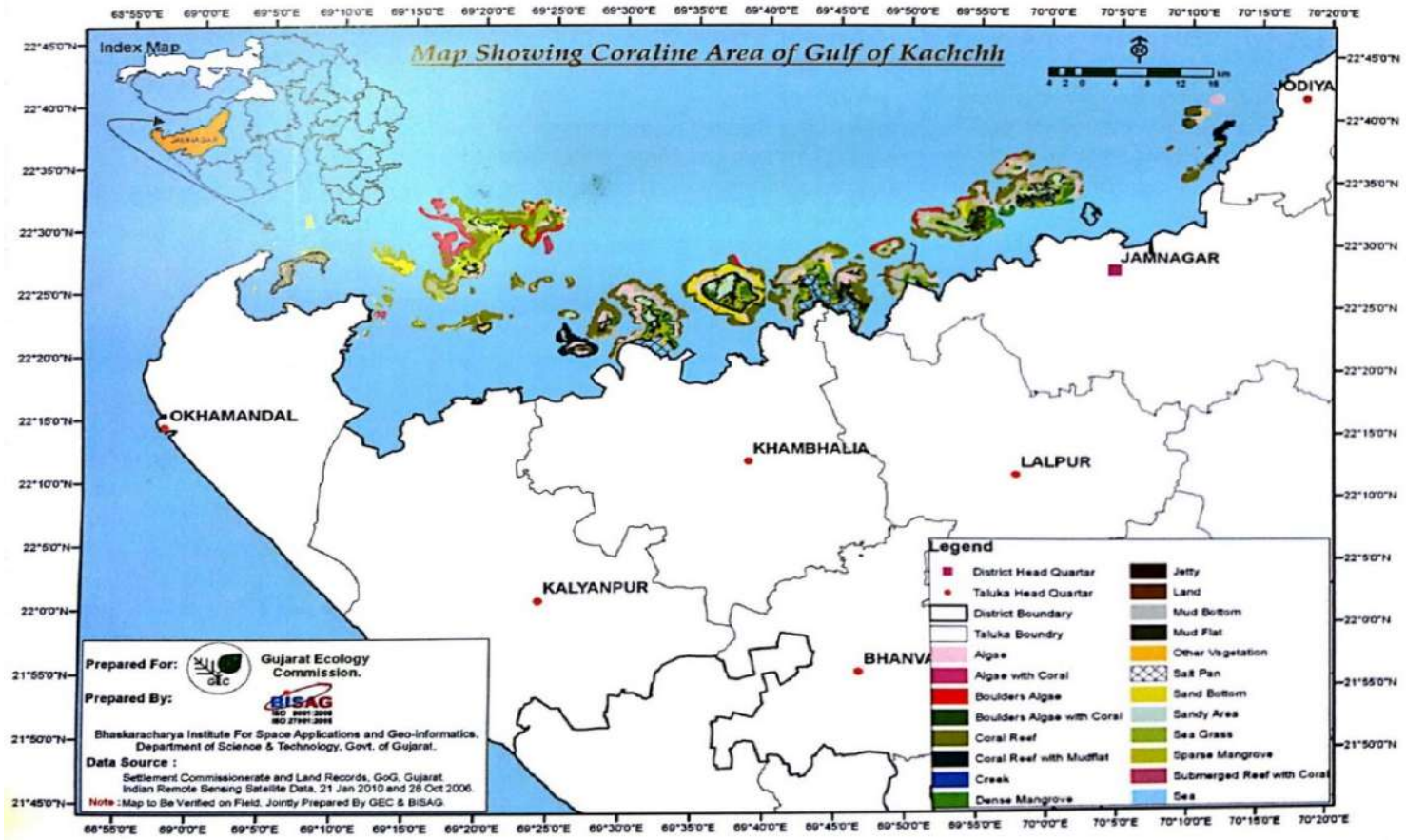


Figure 12.43. Status of Coral Reef in Mithapur Bay (Ref-Coral Reef Atlas by GEC)

Annexure-1

STANDARDS FOR SEA WATER QUALITY CRITERIA

Sr. No.	Parameters	STANDARDS				
		SW 1 For Salt Pans, Shell Fishing, mariculture and Ecologically Sensitive Zone	SW 2 For Bathing, Contact Water Sports and Commercial Fishing	SW 3 For Industrial Cooling, Recreation (non contact) and Aesthetics	SW 4 For Harbour Waters	SW 5 For Navigation and Controlled Waste Disposal
1	pH Range	6.5-8.5	6.5-8.5	6.5-8.5	6.5- 9.0	6.5- 9.0
2	Dissolved Oxygen	5.0 mg/l or 60 % saturation value whichever is higher	4.0 mg/l or 50 % saturation value whichever is higher	3.0 mg/l or 40 % saturation value whichever is higher	3.0 mg/l or 40 % saturation value whichever is higher	3.0 mg/l or 40 % saturation value whichever is higher
3	Colour & Odour	No noticeable colour or offensive odour	No noticeable colour or offensive odour	No noticeable colour or offensive odour	No visble colour or offensive odour	None in such concentrations that would impair any usage specifically assigned to this class
4	Floating materials, Oil grease and Scum (including petroleum products)	Nothing obnoxious or detrimental for use purpose	Nothing obnoxious or detrimental for use purpose	No visible obnoxious floating debris, oil slick, scum	10 mg/l	-
5	Suspended Solids	None from sewage or industrial Waste origin	-	-	-	-
6	Oil & Grease (including petroleum products)	0.1 mg/l	-	-	-	-
7	Heavy Metals: Mercury (as Hg) Cadmium (as Cd) Lead (as Pb)	0.01 mg/l 0.01 mg/l 0.01 mg/l	-	-	-	-
8	Turbidity	-	30 NTU	30 NTU	-	-
9	Dissolved Iron (as Fe)	-	-	0.5 mg/l or less	-	-
10	Dissolved Manganese (as Mn)	-	-	0.5 mg/l or less	-	-
11	Fecalcoliform	-	100/100 ml (MPN)	500/100 ml (MPN)	500/100 ml (MPN)	500/100 ml (MPN)
12	Biochemical Oxygen Demand (3 days at 27oC)	-	3 mg/l	-	5 mg/l	-
13	Sludge Deposits	-	-	-	-	None except for soild refuse floating such small amount that may solids, oil, grease, result from discharge and scum of appropriately teatd swage and / or industrial waste effluents

Annexure-2: Sea Water quality nearby treated waste water discharge

Location of Sample: Sea Water Sample, Down stream of M/S Tata Chemicals Ltd, at village Arambhada. Sample Collected by: Jamnagar Office

Name of parameter	Date of collection												
	05/10/11	06/11/11	08/12/11	09/01/12	04/02/12	01/03/12	02/04/12	06/05/12	08/06/12	05/07/12	10/08/12	08/09/12	Average
Temperature C^0	29	28	29	26	27	26	27	30	32	30	30	29	28.58
pH unit	8.19	8.01	8.33	8.18	8.08	8.04	8.33	8.28	8.17	8.13	8.19	8.11	8.17
Colour as pt.co.scale	5	5	5	5	5	5	5	5	5	5	5	5	5
Turbidity (NTU)	12	18	16	12	12	8	12	12	14	12	13	38.8	14.98
Electrical Conductivity (µs/cm)	49200	44600	42900	43900	45800	48400	46300	49600	48900	52300	55900	48800	48050
Chloride(as Cl) (mg/l)	23000	22500	21500	21500	23000	22500	24740	24243	29741	24887	23492.75	22243	23612
Sulphate (as SO4) (mg/l)	1247	1266	1247	1257	1276	2022	2099	2089	2422	2011	2194.99	2088	1768
Phosphate (as PO4) (mg/l)	0.026	0.047	0.057	0.052	0.042	0.034	0.16	0.037	0.038	-	-	0.022	0.052
Nitrate (mg/l)	0.19	0.16	0.2	0.17	0.21	0.13	0.18	0.12	0.15	0.29	0.31	0.24	0.195
Suspended Solid (mg/l)	18	22	24	18	16	12	16	18	22	32	-	28	20.55
Total Dissolve Solid (mg/l)	43160	40136	38112	39258	41286	43456	41746	44632	44668	42926	54954	40634	42914
Salinity (0/00)	37.9	37.6	38	36.7	37.2	36.8	37.2	37.2	39.3	40.8	40.8	37.9	38.1
Ammonical Nitrogen (mg/l)	0.28	0.36	0.28	0.28	0.28	0.39	0.25	0.42	0.36	0.28	0.84	0.56	0.38
Oil & grease (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	B.D.L	B.D.L	B.D.L.	B.D.L.
Total Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Fecal Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chemical Oxygen Demand (mg/l)	N.R	N.R	N.R	N.R	N.R	N.R	N.R	Due to high Cl	Due to high Cl	Due to high Cl	Due to high Cl	Due to high Cl	N.R
Biochemical Oxygen Demand (mg/l)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
D.O (mg/l)	5.1	5	5	5.1	5.2	5.2	4.9	5.1	5.2	4.98	5.24	5.15	5.10
Boron (mg/l)	0.61	0.78	0.74	0.47	0.59	0.85	0.84	0.87	0.88	0.99	0.84	0.9	0.78
Fluoride (as F) (mg/l)	0.13	0.11	0.09	0.16	0.13	0.19	0.052	0.10	0.11	0.87	0.39	0.39	0.23
Phenolic Compounds (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	B.D.L	B.D.L	B.D.L.	B.D.L.
Cyanide (as CN) (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	B.D.L	B.D.L	B.D.L.	B.D.L.
Hexavalent Chromium (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	B.D.L	B.D.L	B.D.L.	B.D.L.
Total Chromium (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	0.083	0.035	0.122	0.080
Copper (mg/l)	0.04	0.01	B.D.L	0.028	B.D.L	-	0.043	0.042	0.038	0.077	0.067	0.06	0.045
Lead (mg/l)	-	-	-	-	-	-	0.064	0.028	0.049	0.039	0.04	0.041	0.044

Annexure-2: Sea Water quality nearby treated waste water discharge

Location of sample: Sea water sample at D/s of out fall of Tata Chemicals, Vill: Arambhda

Sample collected by: Jamnagar Office

Name of parameter	Date of collection												
	25/10/10	24/11/10	9/12/10	19/01/11	25/02/11	05/03/11	22/04/11	02/05/11	28/06/11	08/07/11	04/08/11	08/09/11	Average
Temperature C°	36	28	24	24	28	27	28	29	29	25	33	27	28.17
pH unit	8.05	8.14	8.38	8.11	8.32	8.31	8.32	8.23	8.22	8.27	8.16	8.29	8.23
Colour as pt.co.scale	05	05	05	05	05	05	05	05	05	05	05	05	5
Turbidity (NTU)	12	14	28	35.9	14	12	10	08	12	12	12	15	15
Electrical Conductivity (µs/cm)	68400	58400	79100	42300	42800	44100	44600	44100	44300	44700	46800	48100	50642
Chloride(as Cl) (mg/l)	26000	28500	38000	24500	23500	29000	25500	25000	27500	23000	22500	24000	26417
Sulphate (as SO4) (mg/l)	1326	1240	2317	1278	1288	1259	1356	1356	1365	1269	1269	1269	1383
Phosphate (as PO4) (mg/l)	0.047	0.061	0.052	0.032	0.036	0.05	0.04	0.035	0.038	0.057	0.04	0.047	0.045
Nitrate (mg/l)	0.035	0.07	0.097	0.055	0.052	0.07	0.052	0.07	0.09	0.13	0.06	0.18	0.080
Suspended Solid (mg/l)	162	118	218	12	12	10	12	12	18	14	16	28	53
Total Dissolve Solid (mg/l)	41104	42852	68638	42724	39594	40086	41302	41312	40684	40898	43664	40734	43633
Salinity (0/00)	42.8	42.8	42.8	35.9	37.3	37.2	37.6	38.0	38	36.8	39.7	37.2	38.8
Ammonical Nitrogen (mg/l)	0.56	0.56	0.28	0.28	0.28	0.28	0.28	0.28	0.56	0.28	0.28	0.56	0.37
Oil & grease (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Fecal Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chemical Oxygen Demand (mg/l)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Biological Oxygen Demand (mg/l)	1.12	0.75	1.5	2.67	1.87	2.25	2.25	2.25	3.0	<5	<5	<5	1.96
D.O (mg/l)	4.1	3.9	4.7	5.20	5.10	5.20	5.10	5.30	5.40	5.20	5.00	5.00	4.9
Boron (mg/l)	0.002	0.021	0.009	0.004	1.18	1.06	1.22	0.99	0.91	0.95	0.48	0.76	0.632
Fluoride (as F) (mg/l)	0.051	0.062	0.045	0.10	0.24	0.17	0.17	0.16	0.16	0.18	0.09	0.09	0.127
Phenolic Compounds (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cyanide (as CN) (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexavalent Chromium (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Chromium (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL .	BDL	BDL	BDL	BDL

Annexure-3: Treated Waste Water Quality Monitoring Reports

Location of Sample: Sea Water Basin Outlet of M/S Tata Chemicals Ltd., Mithapur. (After dilution & after setting)

Sample Collected by: Jamnagar Office

Name of parameter	Date of collection												
	05/10/11	06/11/11	08/12/11	09/01/12	04/02/12	01/03/12	02/04/12	05/05/12	08/06/12	05/07/12	10/08/12	08/09/12	Average
Temperature C^0	30	29	30	33	27	28	28	31	31	31	30	30	29.83
pH unit	8.19	8.23	8.89	8.59	8.39	8.19	8.39	8.32	8.42	7.35	8.31	8.44	8.31
Colour as pt.co.scale	5	5	5	5	5	5	5	5	5	5	5	5	5
Turbidity (NTU)	28	28	32	38	42	38	38	36	38	27	38	61.6	37.05
Electrical Conductivity (µs/cm)	81800	71300	73800	71900	67300	71400	77600	80800	79600	76500	75900	76900	75400
Chloride(as Cl) (mg/l)	39500	36500	37500	34500	34000	35000	44482	44736	45486	36027	36239.12	38738	38559
Sulphate (as SO4) (mg/l)	1371	1362	1390	1352	1342	2333	2867	2644	4344	2611	2633.13	3566	2317
Phosphate (as PO4) (mg/l)	0.032	0.067	0.065	0.072	0.06	0.045	0.24	0.051	0.047	0.087	0.092	0.030	0.074
Nitrate (mg/l)	0.24	0.19	0.24	0.2	0.29	0.23	0.20	0.21	0.13	0.225	0.24	0.29	0.224
Suspended Solid (mg/l)	68	68	38	58	54	84	68	78	82	70	80	84	69.33
Total Dissolve Solid (mg/l)	72794	64208	66616	64760	60570	64454	70104	72156	72148	67666	67112	64258	67237
Salinity (0/00)	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8
Ammonical Nitrogen (mg/l)	0.56	0.59	0.67	0.59	1.4	1.12	0.56	0.81	1.68	1.12	4.2	2.8	1.34
Oil & grease (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	N.D	ND	ND	B.D.L	B.D.L	B.D.L	B.D.L
Total Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Fecal Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chemical Oxygen Demand (mg/l)	N.R	N.R	N.R	N.R	N.R	N.R	Due to high Cl	Due to high Cl	Due to high Cl	NR Due to high Cl	NR Due to high Cl	NR Due to high Cl	N.R
Biochemical Oxygen Demand (mg/l)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
D.O (mg/l)	4.1	4.1	4.6	4.7	4.8	4.2	4.2	4.6	4.1	4.53	4.6	4.69	4.44
Boron (mg/l)	0.89	1.21	0.93	0.76	0.74	1.19	1.19	1.04	1.054	1.22	0.97	1.005	1.017
Fluoride (as F) (mg/l)	0.16	0.18	0.11	0.18	0.18	0.19	0.063	0.15	0.16	0.84	0.42	0.42	0.254
Phenolic Compounds (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	B.D.L	B.D.L	B.D.L	B.D.L
Cyanide (as CN) (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	B.D.L	B.D.L	B.D.L	B.D.L
Hexavalent Chromium (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	B.D.L	B.D.L	B.D.L	B.D.L
Total Chromium (mg/l)	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	ND	ND	ND	0.012	0.075	0.127	0.071
Copper (mg/l)	0.051	0.033	B.D.L	0.053	B.D.L	-	0.06	0.067	0.098	0.037	0.083	0.072	0.062
Lead (mg/l)	-	-	-	-	-	-	0.051	0.047	0.082	0.042	0.044	0.051	0.052

Annexure-3: Treated Waste Water Quality Monitoring Reports

Location of sample: Final Outlet of Tata Chemicals, Mithapur

Sample collected by: Jamnagar Office

Name of parameter	Date of collection												
	25/10/10	24/11/10	09/12/10	19/01/11	25/02/11	05/03/11	22/04/11	02/05/11	28/06/11	08/07/11	04/08/11	08/09/11	Average
Temperature C^0	36	28	24	26	29	26	29	30	29	26	34	28	29
pH unit	8.05	8.14	8.38	8.21	8.46	8.35	8.89	8.87	8.34	8.28	8.22	8.66	8.40
Colour as pt.co.scale	05	05	05	05	05	05	05	05	05	05	05	05	5
Chloride(as Cl) (mg/l)	26000	28500	38000	37500	30500	48500	43000	42500	41000	35500	40000	38000	37417
Sulphate (as SO4) (mg/l)	1326	1240	2317	2288	1326	1374	1423	1430	2154	1499	1433	2298	1676
Phosphate (as PO4) (mg/l)	0.047	0.061	0.052	0.047	0.047	0.07	0.047	0.047	0.047	0.072	0.05	0.09	0.056
Nitrate (mg/l)	0.035	0.07	0.097	0.095	0.08	0.13	0.08	0.095	0.13	0.14	0.07	0.21	0.103
Suspended Solid (mg/l)	162	118	218	82	82	68	38	36	68	72	52	76	89
Total Dissolve Solid (mg/l)	41104	42852	68638	69638	64754	73776	69250	69304	69926	62380	69652	69982	64271
Salinity (0/00)	42.8	42.8	42.8	42.80	42.80	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8
Ammonical Nitrogen (mg/l)	0.56	0.56	0.28	0.56	0.56	0.56	0.56	0.56	1.96	0.56	0.56	0.84	0.68
Oil & grease (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Fecal Coliform (MPN/100 ML)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chemical Oxygen Demand (mg/l)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Biological Oxygen Demand (mg/l)	1.12	0.75	1.5	0.75	0.75	1.12	0.17	1.12	0.75	<5	<5	<5	0.89
D.O (mg/l)	4.1	3.9	4.7	4.10	4.30	4.30	4.70	4.20	4.20	4.10	4.10	4.80	4.3
Boron (mg/l)	0.002	0.021	0.009	0.011	1.39	1.42	1.43	1.33	1.23	1.38	0.69	--	0.810
Fluoride (as F) (mg/l)	0.051	0.062	0.045	0.13	0.21	0.033	0.21	0.21	0.20	0.21	0.13	0.11	0.133
Phenolic Compounds (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cyanide (as CN) (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexavalent Chromium (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Chromium (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

OKHA (GULF OF KACHCHH) – INDIA

LAT. 22° 28′ N. LONG. 69° 05′ E.

TIME ZONE -0530 — TIMES AND HEIGHTS OF HIGH AND LOW WATERS — YEAR 2017

JANUARY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 SU	0242	3.88	16 M	0321	3.97
	0839	1.31		0925	0.92
	1413	3.04		1519	3.15
	2026	0.55		2125	0.72
2 M	0314	3.85	17 TU	0357	3.83
	0917	1.26		1010	0.93
	1456	3.00		1616	3.03
	2105	0.70		2210	1.06
3 TU	0346	3.80	18 W	0435	3.66
	0959	1.19		1059	0.98
	1546	2.96		1718	2.93
	2150	0.90		2301	1.40
4 W	0423	3.74	19 TH	0519	3.45
	1047	1.10		1153	1.03
	1654	2.93		1829	2.87
	2242	1.15			
5 TH	0506	3.64	20 F	0001	1.70
	1143	1.00		0608	3.23
	1817	2.96		1252	1.07
	2346	1.42		1948	2.90
6 F	0558	3.51	21 SA	0119	1.92
	1246	0.88		0706	3.02
	1941	3.08		1354	1.07
				2103	3.01
7 SA	0100	1.65	22 SU	0242	2.00
	0702	3.36		0813	2.87
	1352	0.72		1453	1.02
	2100	3.28		2207	3.17
8 SU	0219	1.78	23 M	0359	1.96
	0809	3.24		0918	2.81
	1456	0.55		1546	0.92
	2207	3.51		2258	3.34
9 M	0335	1.78	24 TU	0457	1.85
	0914	3.18		1014	2.81
	1553	0.36		1631	0.80
	2306	3.73		2337	3.49
10 TU	0440	1.67	25 W	0539	1.72
	1012	3.19		1059	2.87
	1647	0.18		1711	0.66
	2356	3.91			
11 W	0534	1.50	26 TH	0012	3.61
	1105	3.25		0611	1.58
	1737	0.04		1139	2.95
				1747	0.52
12 TH	0041	4.04	27 F	0045	3.72
	0624	1.31		0641	1.44
	1156	3.30		1215	3.04
	1825	-0.02		1824	0.41
13 F	0124	4.11	28 SA	0116	3.81
	0710	1.14		0712	1.30
	1248	3.33		1250	3.12
	1913	0.03		1859	0.36
14 SA	0205	4.12	29 SU	0148	3.87
	0755	1.01		0744	1.16
	1337	3.31		1328	3.17
	1958	0.18		1935	0.38
15 SU	0244	4.07	30 M	0219	3.88
	0840	0.94		0818	1.05
	1427	3.25		1406	3.17
	2042	0.42		2012	0.49
			31 TU	0247	3.85
				0853	0.94
				1447	3.16
				2050	0.65

FEBRUARY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 W	0314	3.81	16 TH	0349	3.54
	0931	0.84		1010	0.83
	1535	3.14		1633	3.06
	2132	0.87		2217	1.37
2 TH	0345	3.73	17 F	0426	3.36
	1016	0.76		1052	0.92
	1637	3.13		1729	2.98
	2223	1.13		2306	1.64
3 F	0424	3.61	18 SA	0506	3.15
	1108	0.70		1142	1.02
	1753	3.13		1835	2.94
	2323	1.42			
4 SA	0515	3.43	19 SU	0012	1.86
	1210	0.67		0557	2.93
	1916	3.18		1242	1.10
				1951	2.96
5 SU	0036	1.68	20 M	0138	1.98
	0619	3.21		0704	2.75
	1319	0.65		1349	1.13
	2037	3.30		2105	3.06
6 M	0159	1.83	21 TU	0305	1.96
	0742	3.03		0827	2.67
	1430	0.59		1457	1.07
	2155	3.47		2210	3.21
7 TU	0327	1.81	22 W	0420	1.83
	0907	2.97		0939	2.70
	1539	0.49		1556	0.94
	2258	3.65		2302	3.38
8 W	0437	1.64	23 TH	0509	1.65
	1016	3.02		1035	2.82
	1640	0.36		1644	0.78
	2349	3.80		2343	3.54
9 TH	0530	1.42	24 F	0544	1.46
	1113	3.12		1120	2.96
	1730	0.24		1726	0.62
10 F	0032	3.91	25 SA	0017	3.66
	0615	1.19		0615	1.27
	1204	3.24		1201	3.11
	1817	0.18		1804	0.49
11 SA	0110	3.96	26 SU	0049	3.76
	0656	0.98		0646	1.07
	1250	3.31		1239	3.24
	1902	0.21		1841	0.43
12 SU	0147	3.96	27 M	0119	3.82
	0737	0.83		0717	0.89
	1334	3.33		1317	3.33
	1942	0.35		1917	0.45
13 M	0218	3.91	28 TU	0147	3.82
	0816	0.76		0749	0.73
	1416	3.30		1357	3.38
	2022	0.56		1954	0.55
14 TU	0247	3.82			
	0854	0.74			
	1458	3.23			
	2100	0.82			
15 W	0317	3.70			
	0931	0.77			
	1543	3.15			
	2136	1.10			

MARCH

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 W	0211	3.79	16 TH	0236	3.52
	0825	0.60		0851	0.65
	1437	3.39		1515	3.32
	2033	0.72		2107	1.20
2 TH	0237	3.73	17 F	0305	3.39
	0903	0.50		0924	0.71
	1524	3.39		1557	3.27
	2117	0.93		2143	1.39
3 F	0310	3.65	18 SA	0338	3.24
	0946	0.46		0959	0.81
	1623	3.37		1644	3.20
	2207	1.18		2227	1.59
4 SA	0352	3.50	19 SU	0413	3.06
	1038	0.49		1041	0.94
	1733	3.34		1737	3.13
	2308	1.44		2323	1.76
5 SU	0447	3.28	20 M	0501	2.87
	1140	0.58		1133	1.08
	1852	3.33		1841	3.09
6 M	0022	1.66	21 TU	0042	1.89
	0600	3.03		0608	2.70
	1252	0.70		1242	1.19
	2016	3.38		1955	3.10
7 TU	0152	1.76	22 W	0211	1.89
	0744	2.86		0738	2.61
	1413	0.76		1402	1.21
	2136	3.48		2111	3.20
8 W	0327	1.67	23 TH	0331	1.76
	0918	2.86		0904	2.67
	1531	0.73		1514	1.12
	2242	3.61		2212	3.34
9 TH	0433	1.46	24 F	0428	1.54
	1031	2.98		1010	2.83
	1633	0.64		1612	0.98
	2333	3.70		2259	3.49
10 F	0520	1.22	25 SA	0509	1.31
	1127	3.13		1102	3.04
	1723	0.55		1659	0.83
				2337	3.61
11 SA	0015	3.76	26 SU	0543	1.06
	0601	1.00		1144	3.24
	1214	3.26		1740	0.71
	1807	0.52			
12 SU	0050	3.78	27 M	0010	3.69
	0638	0.81		0614	0.82
	1252	3.35		1225	3.42
	1848	0.55		1818	0.66
13 M	0120	3.76	28 TU	0038	3.73
	0714	0.68		0646	0.59
	1328	3.39		1304	3.56
	1924	0.66		1856	0.68
14 TU	0145	3.70	29 W	0104	3.73
	0748	0.62		0720	0.40
	1402	3.39		1345	3.64
	1959	0.82		1935	0.77
15 W	0209	3.62	30 TH	0131	3.70
	0820	0.61		0757	0.28
	1437	3.37		1429	3.67
	2033	1.01		2016	0.91
			31 F	0202	3.63
				0836	0.23
				1517	3.67
				2103	1.09

APRIL

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 SA	0240	3.53	16 SU	0258	3.13
	0922	0.27		0919	0.74
	1613	3.64		1610	3.45
	2156	1.28		2202	1.58
2 SU	0329	3.36	17 M	0335	3.00
	1014	0.40		0957	0.87
	1718	3.59		1657	3.38
	2259	1.46		2252	1.69
3 M	0433	3.13	18 TU	0423	2.85
	1118	0.61		1045	1.03
	1832	3.53		1751	3.32
				2358	1.78
4 TU	0017	1.58	19 W	0530	2.71
	0603	2.91		1147	1.19
	1234	0.83		1856	3.28
	1952	3.51			
5 W	0148	1.59	20 TH	0121	1.77
	0754	2.82		0700	2.64
	1359	0.98		1306	1.30
	2110	3.53		2008	3.30
6 TH	0315	1.45	21 F	0239	1.64
	0927	2.91		0829	2.72
	1521	1.01		1426	1.30
	2217	3.58		2112	3.38
7 F	0417	1.24	22 SA	0341	1.41
	1038	3.07		0942	2.92
	1623	0.98		1534	1.23
	2309	3.61		2206	3.47
8 SA	0504	1.03	23 SU	0427	1.14
	1132	3.23		1040	3.17
	1712	0.94		1627	1.13
	2350	3.61		2248	3.55
9 SU	0542	0.85	24 M	0505	0.85
	1214	3.35		1126	3.41
	1754	0.94		1712	1.04
				2322	3.60
10 M	0022	3.59	25 TU	0539	0.57
	0615	0.71		1208	3.62
	1249	3.44		1753	1.00
	1832	0.98		2351	3.64
11 TU	0048	3.54	26 W	0614	0.32
	0648	0.61		1250	3.78
	1319	3.49		1835	1.00
	1907	1.05			
12 W	0110	3.48	27 TH	0022	3.64
	0717	0.57		0652	0.14
	1348	3.52		1334	3.88
	1940	1.15		1917	1.05
13 TH	0133	3.41	28 F	0057	3.61
	0745	0.56		0733	0.06
	1419	3.53		1419	3.92
	2011	1.25		2004	1.13
14 F	0158	3.33	29 SA	0135	3.54
	0815	0.59		0816	0.08
	1453	3.52		1510	3.92
	2043	1.36		2053	1.23
15 SA	0226	3.24	30 SU	0222	3.42
	0844	0.64		0904	0.20
	1529	3.49		1603	3.87
	2119	1.47		2149	1.32

OKHA (GULF OF KACHCHH) – INDIA

LAT. 22° 28′ N. LONG. 69° 05′ E.

TIME ZONE -0530 — TIMES AND HEIGHTS OF HIGH AND LOW WATERS — YEAR 2017

MAY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 M	0319	3.25	16 TU	0311	2.98
	0959	0.42		0929	0.81
	1704	3.80		1628	3.58
	2252	1.39		2228	1.61
2 TU	0434	3.06	17 W	0359	2.88
	1101	0.70		1016	0.97
	1810	3.72		1715	3.53
				2325	1.63
3 W	0007	1.43	18 TH	0505	2.79
	0611	2.91		1111	1.15
	1214	0.98		1811	3.48
	1921	3.63			
4 TH	0131	1.38	19 F	0034	1.59
	0751	2.90		0631	2.75
	1338	1.20		1219	1.33
	2034	3.58		1912	3.44
5 F	0250	1.24	20 SA	0147	1.45
	0919	3.01		0757	2.84
	1501	1.30		1338	1.44
	2141	3.54		2015	3.43
6 SA	0352	1.07	21 SU	0250	1.23
	1031	3.19		0912	3.04
	1606	1.33		1451	1.46
	2235	3.50		2110	3.45
7 SU	0438	0.91	22 M	0342	0.95
	1125	3.34		1014	3.29
	1658	1.34		1552	1.43
	2318	3.44		2156	3.47
8 M	0518	0.78	23 TU	0426	0.66
	1205	3.46		1106	3.54
	1742	1.35		1644	1.38
	2350	3.37		2235	3.50
9 TU	0550	0.68	24 W	0505	0.38
	1238	3.53		1151	3.75
	1818	1.37		1730	1.32
				2312	3.53
10 W	0014	3.31	25 TH	0546	0.15
	0621	0.61		1236	3.92
	1306	3.58		1817	1.28
	1852	1.40		2351	3.55
11 TH	0036	3.26	26 F	0629	0.00
	0648	0.57		1321	4.03
	1331	3.62		1903	1.25
	1923	1.43			
12 F	0100	3.22	27 SA	0034	3.53
	0714	0.55		0713	-0.04
	1401	3.66		1409	4.07
	1952	1.46		1954	1.24
13 SA	0127	3.18	28 SU	0121	3.46
	0744	0.56		0801	0.03
	1433	3.68		1500	4.07
	2025	1.49		2044	1.24
14 SU	0158	3.13	29 M	0216	3.35
	0816	0.60		0851	0.21
	1508	3.67		1550	4.02
	2101	1.52		2139	1.24
15 M	0232	3.07	30 TU	0319	3.21
	0851	0.69		0945	0.46
	1546	3.64		1644	3.94
	2142	1.57		2240	1.24
			31 W	0435	3.07
				1044	0.77
				1742	3.83
				2346	1.23

JUNE

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 TH	0601	2.97	16 F	0445	2.89
	1151	1.10		1044	1.10
	1843	3.69		1727	3.59
				2350	1.33
2 F	0100	1.19	17 SA	0604	2.87
	0730	2.96		1144	1.32
	1309	1.37		1821	3.52
	1949	3.55			
3 SA	0213	1.10	18 SU	0055	1.20
	0857	3.05		0727	2.95
	1430	1.54		1256	1.51
	2053	3.43		1920	3.44
4 SU	0317	0.99	19 M	0159	1.01
	1010	3.21		0844	3.12
	1541	1.61		1411	1.63
	2150	3.33		2018	3.37
5 M	0407	0.88	20 TU	0257	0.78
	1105	3.37		0950	3.35
	1640	1.63		1518	1.66
	2238	3.24		2111	3.34
6 TU	0448	0.79	21 W	0349	0.53
	1149	3.48		1047	3.58
	1726	1.62		1619	1.61
	2315	3.17		2200	3.35
7 W	0523	0.72	22 TH	0438	0.29
	1221	3.56		1136	3.78
	1805	1.61		1713	1.52
	2344	3.11		2245	3.39
8 TH	0553	0.66	23 F	0525	0.09
	1248	3.61		1224	3.94
	1838	1.60		1804	1.40
				2333	3.43
9 F	0010	3.08	24 SA	0612	-0.04
	0621	0.61		1310	4.06
	1313	3.66		1853	1.28
	1907	1.57			
10 SA	0036	3.08	25 SU	0024	3.43
	0650	0.56		0700	-0.06
	1342	3.71		1358	4.11
	1937	1.54		1942	1.17
11 SU	0107	3.09	26 M	0116	3.40
	0721	0.54		0749	0.04
	1415	3.75		1444	4.11
	2009	1.50		2033	1.10
12 M	0140	3.09	27 TU	0213	3.33
	0755	0.56		0839	0.23
	1450	3.76		1531	4.05
	2044	1.48		2124	1.05
13 TU	0216	3.05	28 W	0315	3.23
	0832	0.63		0929	0.49
	1525	3.74		1617	3.96
	2122	1.47		2217	1.03
14 W	0256	3.01	29 TH	0421	3.11
	0911	0.74		1021	0.82
	1603	3.70		1705	3.82
	2204	1.45		2315	1.04
15 TH	0343	2.95	30 F	0534	3.02
	0953	0.90		1120	1.16
	1642	3.65		1757	3.64
	2254	1.40			

JULY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 SA	0018	1.05	16 SU	0537	3.00
	0655	2.97		1116	1.30
	1231	1.47		1729	3.48
	1856	3.43			
2 SU	0126	1.04	17 M	0010	0.93
	0816	3.02		0657	3.04
	1348	1.69		1224	1.54
	1958	3.25		1827	3.35
3 M	0230	1.00	18 TU	0114	0.82
	0932	3.14		0816	3.17
	1507	1.79		1338	1.71
	2100	3.10		1933	3.21
4 TU	0327	0.94	19 W	0220	0.68
	1034	3.29		0929	3.36
	1614	1.79		1456	1.76
	2155	3.01		2040	3.14
5 W	0414	0.87	20 TH	0322	0.50
	1120	3.42		1031	3.55
	1708	1.74		1604	1.69
	2240	2.96		2142	3.15
6 TH	0454	0.79	21 F	0419	0.32
	1156	3.51		1125	3.74
	1750	1.69		1704	1.54
	2316	2.94		2237	3.21
7 F	0527	0.71	22 SA	0511	0.15
	1225	3.58		1212	3.89
	1822	1.63		1756	1.34
	2349	2.96		2329	3.30
8 SA	0558	0.61	23 SU	0601	0.03
	1253	3.64		1257	4.00
	1850	1.56		1843	1.14
9 SU	0019	3.01	24 M	0021	3.37
	0631	0.53		0649	0.01
	1323	3.70		1341	4.05
	1920	1.48		1930	0.98
10 M	0052	3.07	25 TU	0114	3.39
	0704	0.47		0737	0.09
	1355	3.75		1423	4.04
	1951	1.39		2015	0.87
11 TU	0127	3.10	26 W	0208	3.35
	0740	0.48		0822	0.28
	1429	3.77		1504	3.97
	2023	1.32		2101	0.82
12 W	0204	3.10	27 TH	0301	3.27
	0816	0.54		0908	0.55
	1501	3.75		1542	3.85
	2100	1.26		2148	0.83
13 TH	0243	3.08	28 F	0357	3.17
	0853	0.66		0955	0.87
	1534	3.72		1623	3.68
	2138	1.19		2235	0.87
14 F	0328	3.04	29 SA	0458	3.06
	0934	0.83		1047	1.21
	1606	3.67		1706	3.48
	2220	1.11		2329	0.95
15 SA	0424	3.01	30 SU	0607	2.99
	1020	1.05		1147	1.52
	1642	3.59		1756	3.24
	2311	1.02			
			31 M	0029	1.02
				0723	2.97
				1303	1.76
				1856	3.02

AUGUST

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 TU	0134	1.06	16 W	0039	0.71
	0840	3.04		0754	3.23
	1425	1.87		1320	1.74
	2005	2.85		1903	3.00
2 W	0236	1.05	17 TH	0152	0.69
	0948	3.16		0911	3.37
	1542	1.85		1446	1.76
	2111	2.77		2032	2.93
3 TH	0332	0.99	18 F	0304	0.60
	1041	3.29		1019	3.53
	1642	1.76		1602	1.62
	2207	2.78		2145	2.99
4 F	0421	0.89	19 SA	0409	0.46
	1123	3.41		1115	3.69
	1727	1.65		1659	1.40
	2251	2.84		2244	3.10
5 SA	0502	0.76	20 SU	0504	0.31
	1157	3.50		1200	3.81
	1800	1.54		1746	1.15
	2329	2.93		2336	3.25
6 SU	0537	0.63	21 M	0551	0.21
	1229	3.58		1242	3.89
	1828	1.42		1829	0.92
7 M	0004	3.03	22 TU	0025	3.37
	0612	0.51		0638	0.19
	1259	3.66		1320	3.92
	1856	1.29		1912	0.75
8 TU	0038	3.13	23 W	0112	3.43
	0648	0.44		0721	0.27
	1331	3.71		1355	3.89
	1927	1.16		1952	0.64
9 W	0114	3.20	24 TH	0157	3.42
	0721	0.44		0804	0.46
	1401	3.73		1429	3.79
	1958	1.05		2032	0.62
10 TH	0151	3.22	25 F	0242	3.36
	0757	0.52		0844	0.71
	1429	3.71		1500	3.66
	2032	0.95		2111	0.66
11 F	0229	3.21	26 SA	0329	3.27
	0833	0.66		0925	1.00
	1454	3.66		1535	3.49
	2107	0.86		2150	0.74
12 SA	0311	3.19	27 SU	0419	3.17
	0912	0.85		1010	1.29
	1522	3.60		1613	3.28
	2146	0.77		2234	0.87
13 SU	0404	3.16	28 M	0515	3.07
	0957	1.07		1104	1.56
	1556	3.51		1657	3.05
	2234	0.72		2325	1.01
14 M	0512	3.14	29 TU	0621	3.00
	1052	1.33		1212	1.78
	1642	3.37		1751	2.83
	2332	0.71			
15 TU	0632	3.16	30 W	0027	1.13
	1200	1.58		0735	2.99
	1743	3.18		1335	1.89
				1902	2.66
			31 TH	0135	1.19
				0849	3.06
				1457	1.86
				2025	2.61

OKHA (GULF OF KACHCHH) – INDIA

LAT. 22° 28′ N. LONG. 69° 05′ E.

TIME ZONE -0530 — TIMES AND HEIGHTS OF HIGH AND LOW WATERS — YEAR 2017

SEPTEMBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 F	0244	1.16	16 SA	0254	0.81
	0950	3.17		1003	3.55
	1606	1.73		1559	1.40
	2134	2.67		2200	2.97
2 SA	0343	1.04	17 SU	0403	0.71
	1041	3.31		1058	3.65
	1654	1.56		1651	1.16
	2227	2.81		2259	3.15
3 SU	0433	0.88	18 M	0457	0.60
	1122	3.43		1143	3.72
	1729	1.39		1733	0.92
	2311	2.97		2347	3.32
4 M	0515	0.73	19 TU	0543	0.53
	1157	3.54		1221	3.75
	1800	1.21		1811	0.70
	2349	3.13			
5 TU	0551	0.60	20 W	0029	3.45
	1228	3.62		0625	0.53
	1828	1.03		1253	3.74
				1849	0.55
6 W	0025	3.27	21 TH	0107	3.52
	0627	0.54		0706	0.61
	1257	3.67		1323	3.67
	1857	0.87		1924	0.48
7 TH	0102	3.37	22 F	0145	3.53
	0702	0.54		0744	0.77
	1324	3.67		1349	3.57
	1928	0.72		1959	0.49
8 F	0138	3.41	23 SA	0222	3.50
	0735	0.63		0820	0.97
	1348	3.64		1418	3.45
	2001	0.61		2033	0.55
9 SA	0215	3.42	24 SU	0301	3.43
	0812	0.77		0857	1.19
	1411	3.58		1449	3.30
	2036	0.53		2107	0.66
10 SU	0256	3.41	25 M	0343	3.35
	0853	0.96		0936	1.40
	1440	3.51		1522	3.12
	2115	0.49		2142	0.80
11 M	0346	3.38	26 TU	0430	3.25
	0939	1.17		1023	1.59
	1518	3.39		1603	2.93
	2203	0.52		2224	0.98
12 TU	0452	3.34	27 W	0523	3.16
	1037	1.39		1123	1.75
	1609	3.21		1654	2.74
	2301	0.62		2316	1.16
13 W	0610	3.32	28 TH	0625	3.08
	1147	1.59		1242	1.84
	1718	2.98		1804	2.59
14 TH	0011	0.75	29 F	0027	1.30
	0733	3.34		0738	3.08
	1312	1.69		1402	1.81
	1904	2.81		1935	2.55
15 F	0133	0.83	30 SA	0148	1.33
	0853	3.43		0850	3.15
	1446	1.61		1517	1.67
	2044	2.83		2058	2.66

OCTOBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 SU	0300	1.25	16 M	0353	1.02
	0949	3.27		1034	3.62
	1612	1.46		1634	0.94
	2202	2.85		2306	3.30
2 M	0359	1.10	17 TU	0447	0.97
	1037	3.41		1120	3.62
	1652	1.22		1715	0.74
	2251	3.08		2351	3.47
3 TU	0445	0.95	18 W	0532	0.94
	1115	3.52		1156	3.58
	1725	1.00		1751	0.58
	2332	3.29			
4 W	0526	0.84	19 TH	0029	3.58
	1147	3.59		0612	0.96
	1756	0.78		1225	3.52
				1825	0.47
5 TH	0011	3.46	20 F	0103	3.64
	0603	0.78		0650	1.03
	1215	3.62		1249	3.44
	1827	0.58		1857	0.43
6 F	0048	3.59	21 SA	0133	3.66
	0639	0.78		0727	1.13
	1241	3.61		1313	3.35
	1857	0.42		1927	0.45
7 SA	0124	3.67	22 SU	0204	3.65
	0716	0.85		0801	1.25
	1306	3.57		1340	3.25
	1931	0.31		1957	0.51
8 SU	0202	3.70	23 M	0236	3.62
	0754	0.97		0834	1.37
	1334	3.51		1409	3.15
	2008	0.27		2027	0.62
9 M	0244	3.69	24 TU	0312	3.56
	0837	1.12		0911	1.48
	1408	3.41		1443	3.03
	2050	0.31		2101	0.76
10 TU	0335	3.65	25 W	0353	3.47
	0928	1.28		0953	1.59
	1451	3.26		1522	2.89
	2139	0.43		2139	0.94
11 W	0438	3.59	26 TH	0438	3.39
	1027	1.43		1044	1.68
	1550	3.06		1612	2.74
	2238	0.64		2226	1.13
12 TH	0551	3.53	27 F	0532	3.30
	1140	1.54		1151	1.74
	1716	2.85		1722	2.62
	2351	0.86		2326	1.32
13 F	0710	3.51	28 SA	0632	3.25
	1307	1.54		1309	1.71
	1917	2.77		1850	2.58
14 SA	0117	1.03	29 SU	0046	1.44
	0827	3.53		0741	3.26
	1437	1.39		1420	1.56
	2053	2.89		2020	2.70
15 SU	0244	1.06	30 M	0208	1.45
	0938	3.58		0847	3.32
	1545	1.17		1522	1.34
	2209	3.09		2132	2.92
			31 TU	0317	1.37
				0942	3.41
				1609	1.08
				2227	3.19

NOVEMBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 W	0412	1.26	16 TH	0523	1.35
	1026	3.47		1129	3.38
	1647	0.82		1729	0.54
	2313	3.44			
2 TH	0457	1.17	17 F	0024	3.69
	1102	3.52		0604	1.37
	1720	0.57		1158	3.29
	2353	3.65		1801	0.48
3 F	0537	1.11	18 SA	0055	3.74
	1132	3.53		0641	1.40
	1754	0.35		1221	3.21
				1832	0.46
4 SA	0032	3.81	19 SU	0121	3.75
	0617	1.09		0714	1.44
	1201	3.53		1245	3.15
	1828	0.17		1900	0.47
5 SU	0110	3.92	20 M	0148	3.75
	0657	1.11		0745	1.47
	1232	3.50		1312	3.11
	1906	0.08		1928	0.51
6 M	0151	3.96	21 TU	0218	3.74
	0740	1.17		0816	1.49
	1307	3.43		1342	3.06
	1947	0.10		1959	0.59
7 TU	0236	3.95	22 W	0250	3.72
	0827	1.25		0851	1.52
	1349	3.32		1416	2.99
	2032	0.21		2033	0.70
8 W	0328	3.91	23 TH	0327	3.67
	0919	1.32		0931	1.54
	1440	3.17		1457	2.91
	2124	0.41		2111	0.86
9 TH	0427	3.84	24 F	0407	3.61
	1020	1.38		1016	1.57
	1549	2.99		1546	2.81
	2223	0.67		2155	1.04
10 F	0532	3.75	25 SA	0451	3.54
	1130	1.39		1109	1.57
	1729	2.85		1651	2.72
	2333	0.96		2247	1.24
11 SA	0642	3.67	26 SU	0543	3.48
	1252	1.33		1214	1.53
	1914	2.86		1811	2.68
				2351	1.42
12 SU	0056	1.20	27 M	0642	3.42
	0754	3.61		1324	1.41
	1413	1.18		1940	2.77
	2046	3.01			
13 M	0225	1.32	28 TU	0110	1.56
	0903	3.57		0745	3.39
	1519	0.98		1427	1.21
	2202	3.23		2057	2.98
14 TU	0338	1.35	29 W	0227	1.60
	1002	3.52		0844	3.38
	1610	0.80		1521	0.96
	2301	3.44		2200	3.25
15 W	0435	1.35	30 TH	0334	1.57
	1051	3.46		0934	3.38
	1652	0.65		1606	0.69
	2346	3.60		2251	3.52

DECEMBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 F	0427	1.51	16 SA	0012	3.70
	1016	3.39		0557	1.62
	1645	0.43		1133	3.07
	2336	3.75		1740	0.55
2 SA	0513	1.44	17 SU	0043	3.73
	1052	3.40		0634	1.61
	1723	0.19		1200	3.02
				1810	0.53
3 SU	0017	3.94	18 M	0107	3.74
	0558	1.37		0703	1.58
	1129	3.42		1227	3.01
	1804	0.02		1839	0.51
4 M	0059	4.07	19 TU	0133	3.76
	0643	1.31		0733	1.55
	1208	3.42		1255	3.02
	1848	-0.05		1909	0.51
5 TU	0142	4.13	20 W	0201	3.78
	0730	1.27		0802	1.50
	1253	3.37		1327	3.03
	1933	-0.01		1941	0.54
6 W	0230	4.13	21 TH	0232	3.79
	0820	1.25		0834	1.45
	1342	3.28		1402	3.01
	2020	0.14		2016	0.62
7 TH	0319	4.09	22 F	0305	3.78
	0912	1.23		0910	1.41
	1442	3.17		1443	2.97
	2112	0.37		2053	0.74
8 F	0412	4.01	23 SA	0341	3.75
	1009	1.20		0949	1.38
	1556	3.04		1528	2.90
	2210	0.67		2132	0.90
9 SA	0506	3.90	24 SU	0417	3.70
	1112	1.16		1034	1.34
	1723	2.96		1624	2.84
	2313	1.01		2217	1.10
10 SU	0607	3.77	25 M	0459	3.63
	1222	1.11		1125	1.27
	1853	2.96		1736	2.81
				2313	1.34
11 M	0028	1.32	26 TU	0547	3.54
	0712	3.62		1225	1.17
	1335	1.01		1859	2.86
	2023	3.07			
12 TU	0152	1.54	27 W	0021	1.57
	0818	3.47		0643	3.42
	1443	0.89		1330	1.03
	2143	3.26		2019	3.02
13 W	0312	1.64	28 TH	0137	1.73
	0921	3.34		0744	3.31
	1541	0.76		1430	0.83
	2245	3.46		2131	3.25
14 TH	0420	1.66	29 F	0253	1.79
	1016	3.24		0843	3.23
	1627	0.67		1524	0.60
	2334	3.61		2230	3.51
15 F	0513	1.64	30 SA	0359	1.76
	1059	3.14		0935	3.21
	1706	0.60		1613	0.36
				2319	3.74
			31 SU	0455	1.66
				1021	3.24
				1701	0.14

Annexure-5

TABLE-10

SPECIESWISE MARINE FISH PRODUCTION SINCE 2000-2001 TO 2013-2014

(Production in M.T.)

Sr. No.	Name Of Species	Year														Precent. 2013-14
		2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16
1	White Pomfret	9169	10981	10655	10014	6515	14487	27562	13398	20662	14097	10080	6687	7675	7631	1.10
2	Black Pomfret	2567	3894	4595	2395	1766	2470	5539	2343	4129	3239	2218	2255	3250	2414	0.35
3	Bombayduck	86085	79219	76940	78747	84956	92088	91443	128995	148659	100427	70455	88974	99175	79630	11.45
4	Thread fin	2079	4342	5197	3002	2285	2940	3057	4225	5564	5194	5727	4216	4310	2896	0.42
5	Jewfish	8814	11779	9540	8500	8236	12933	9878	16850	14196	10276	9819	7906	5799	5430	0.78
6	Hilsa	1988	4535	1983	1298	1906	2095	3539	2378	1600	3104	9355	3817	1714	1397	0.20
7	Clupeids	11186	13850	19677	11813	10793	14759	15892	14493	19094	16333	10254	12069	11324	9061	1.30
8	Coilia	9145	11293	12543	11568	11654	8980	9480	9064	9836	10234	14299	10564	11230	11696	1.68
9	Shark	14079	14385	17937	12956	10163	15896	27465	14466	12943	17580	13500	11576	8770	9864	1.42
10	Mullets	5694	5191	5391	4700	4435	6404	6585	6184	5526	4915	4966	6599	5799	5138	0.74
11	Catfish	19568	30001	25990	24899	25979	25851	29594	36085	45094	41668	29889	31263	24971	27705	3.98
12	Eel	2694	3224	3638	2609	3418	6405	6279	6663	5562	4815	2967	4456	4843	3098	0.45
13	Leather Jacket	2291	2752	3166	1481	2336	4654	6751	6163	6495	6558	4997	3068	3184	5208	0.75
14	Seerfish	7706	10971	11881	6873	7388	9277	15866	11127	10574	13124	10365	12126	9634	8308	1.19
15	Indian Salmon	885	1517	1074	897	1002	1252	1950	1290	674	2624	5432	1947	2242	727	0.10
16	Ribbonfish	38429	50754	62852	39423	48135	43179	41118	29708	29231	31288	60344	59407	39061	65971	9.48
17	Silver Bar	3043	6577	8457	3955	3963	4840	10189	6960	6928	5894	6062	6637	5021	5920	0.85
18	Perches	6942	9890	11908	8894	11731	15493	17719	21923	15914	20097	18932	16292	13649	16842	2.42
19	Small Sciaenids	197006	172970	189665	171904	154562	151392	129210	140219	148699	158686	166146	169836	186998	177325	25.49
20	Shrimp	44970	40708	43189	45217	48281	53821	50952	40851	29111	34820	33214	38716	40867	40485	5.82
21	Prawns[Medium]	7905	7093	5760	7365	5949	10390	10305	9922	8771	13865	12871	7944	7209	7862	1.13
22	Prawns[Jembo]	1108	972	947	1615	839	2310	3166	1107	720	951	1917	1732	1580	1081	0.16
23	Lobster	500	406	421	989	273	1302	2275	470	527	379	952	709	797	685	0.10
24	Crab	1787	1348	2633	1869	1657	1989	3499	1997	2435	2433	3326	7949	4712	8617	1.24
25	Levta	2712	2240	2173	1905	1763	2328	3312	2266	1868	2388	1761	2430	3724	3673	0.53
26	Squid/Cuttlefish	22857	22415	35476	27780	17504	36152	26297	20098	18016	22875	35598	30609	26685	26095	3.75
27	Tuna	-	-	-	-	-	-	10028	16644	9487	5066	4772	5967	3639	3942	0.57
28	Carangids/Mackerel	-	-	-	-	-	-	17445	15934	8341	10389	9794	9016	7153	10438	1.50
29	Ranifish	-	-	-	-	-	-	16460	28837	21918	13591	14655	11049	19231	17491	2.51
30	Solefish	-	-	-	-	-	-	5300	8499	7887	9518	4582	6589	11508	10889	1.57
31	Miscellaneous	109265	127522	169950	116468	107462	120197	68607	61689	63394	101017	109681	110083	117806	118061	16.97
	Grand Total	**620474**	**650829**	**743638**	**609136**	**584951**	**663884**	**676762**	**680848**	**683855**	**687445**	**688930**	**692488**	**693560**	**695580**	**100.00**

TABLE-12

DISRTICTWISE MARINE FISH PRODUCTION SINCE 2000-2001 TO 2013-2014

[Prod. in M.T.]

Sr. No.	Year	Valsad	Navsari	Surat	Bharuch	Anand	Rajkot	Kachchh	Jamnagar	Amreli	Junagadh	Porbandar	Bhavnagar	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2000-01	93194	N.A.	9681	2046	1442	1716	64697	72552	52166	318340	N.A.	4640	620474
2	2001-02	65374	24951	6909	1412	1585	2030	80014	83398	36405	270742	74127	3882	650829
3	2002-03	74348	30126	8217	1775	2029	1458	80714	102846	45794	298032	94503	3796	743638
4	2003-04	79721	30048	8882	1638	2016	1744	71995	37957	49753	247559	74003	3820	609136
5	2004-05	78623	33567	8683	1500	2614	1907	64680	45935	59265	233294	49912	4971	584951
6	2005-06	79064	34703	11228	1587	3023	1528	62394	66489	66750	281456	51047	4615	663884
7	2006-07	57739	29955	10414	3789	2276	2709	59353	65232	77776	300804	60437	6278	676762
8	2007-08	41450	15510	9529	6419	264	2280	58724	59225	61624	259763	161486	4574	680848
9	2008-09	35166	8673	3538	6864	421	953	53292	62618	200774	250781	56387	4388	683855
10	2009-10	81354	11345	4488	6078	487	1040	60405	88293	101906	265049	63411	3589	687445
11	2010-11	87497	19428	2525	5804	314	1072	72977	67530	60711	280229	88610	2233	688930
12	2011-12	87594	20159	3208	6405	456	955	72897	67146	60576	280897	89555	2640	692488
13	2012-13	88474	26566	3249	4793	422	529	72781	67808	57634	278097	90786	2421	693560
14	2013-14	92861	28596	3494	4045	336	614	70329	68065	50606	283018	91513	2103	695580
% age 2013-14		**13.35**	**4.11**	**0.50**	**0.58**	**0.05**	**0.09**	**10.11**	**9.79**	**7.28**	**40.69**	**13.16**	**0.30**	**100.00**

NOTE: The separate production data of Navasari and Porbandar are not available for the year 2000-01 and they are included in Valsad and Junagadh district respectivly.

TABLE-14

IMPORTANT MARINE FISH LANDING CENTRES AND ITS PRODUCTION FROM 2000-2001 TO 2013-14

[Production in M.T.]

Sr. No.	Name of Center	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	Percent [2013-14]
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Veraval	174791	172413	195452	152813	139037	196276	188515	126755	128334	126411	177320	185425	181959	191673	27.56
2	Porbandar	55485	72120	91680	71739	47966	49078	52139	54283	48521	54276	84196	82000	84940	88756	12.76
3	Mangrol	36736	36664	23395	25749	24717	19856	21679	25025	38669	73455	54522	49919	48753	59004	8.48
4	Jafrabad	34838	17871	29211	36573	44622	47848	47979	113084	151568	75012	45576	44600	38655	26240	3.77
5	Jakhau	47964	56753	59000	47030	42580	39537	40511	36282	33058	48337	56954	59475	60346	56784	8.16
6	Dwarka	15889	21876	10236	2583	2440	4170	4157	2047	2884	4453	4378	5030	6035	4916	0.71
7	Okha	31506	36030	44749	19770	27991	46207	40674	34819	36310	62115	41660	37751	32634	33378	4.80
8	Rajpara	18623	22008	26212	26790	22405	20285	26680	41383	35119	30490	21662	15586	17337	6811	0.98
9	Navabandar	21745	28654	26922	27902	29416	22243	29552	37069	30007	18675	10634	12405	14242	7955	1.14
10	Umarsadi	13490	16292	15465	14054	14714	14733	8496	5511	4262	7889	10515	13014	10314	11815	1.70
	Total	**451067**	**480681**	**522322**	**425003**	**395888**	**460233**	**460382**	**476258**	**508732**	**501113**	**507417**	**505205**	**495215**	**487332**	**70.06**
Total Production of Other Centers		**169407**	**170148**	**221316**	**184133**	**189063**	**203651**	**216380**	**204590**	**175123**	**186332**	**181513**	**187283**	**198345**	**208248**	**29.94**
Total Production		**620474**	**650829**	**743638**	**609136**	**584951**	**663884**	**676762**	**680848**	**683855**	**687445**	**688930**	**692488**	**693560**	**695580**	**100.00**

TABLE-31

DISTRICTWISE AND CATEGORY WISE INLAND FISH PRODUCTION SINCE 2000-01 TO 2013-14

[Prod. in M.T.]

Sr. No.	Name of District	Year														
		2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2013-14%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Valsad	3480	2885	1682	5870	1470	1151	1016	1095	2322	3067	4439	4448	4899	8060	7.83
2	Navsari	0	1204	2139	2525	3049	4284	2846	2114	7200	5296	6109	6278	6885	10583	10.28
3	The Dangs	0	0	0	0	0	36	0	0	0	0	0	0	0	0	0.00
4	Surat	5386	5522	4616	6046	6896	12087	4480	11107	10663	10583	10447	11851	10864	10174	9.89
5	Tapi	7886	12758	6345	6477	6830	9501	6319	361	9519	10482	10316	11228	11244	10004	9.72
6	Bharuch	7865	7489	8155	5317	7489	8743	26452	21902	15778	14810	14869	12915	11390	10000	9.72
7	Narmada	0	1768	753	4429	5863	5907	5004	4705	5340	5991	6130	6455	6664	6822	6.63
8	Vadodara	1611	1297	1260	4281	3246	2881	2925	3289	10295	8607	8798	7369	7141	7683	7.47
9	PanchMahals	1338	830	657	668	1021	3485	3024	2730	4386	3805	3823	3713	3811	3487	3.39
10	Dohad	0	229	578	879	655	774	1164	1808	712	888	877	909	959	763	0.74
11	Anand	0	2195	2719	2402	2959	3939	5106	5164	5190	5303	5915	6021	5556	6527	6.34
12	Kheda	3346	105	177	485	1036	1563	4041	5437	560	2813	2918	3753	3973	3785	3.68
13	Ahmedabad	4438	1657	1527	1515	1998	2222	2722	3077	3701	3494	3337	4184	4615	7717	7.50
14	Gandhinagar	0	0	0	0	0	14	8	4	20	23	0	0	0	9	0.01
15	Mahesana	32	239	130	131	189	44	94	3781	222	250	30	248	310	497	0.48
16	Patan	0	70	47	77	121	30	10	6	4	0	0	8	10	21	0.02
17	Sabarkantha	240	1182	86	86	220	222	279	604	169	794	786	1351	1397	1436	1.40
18	Banaskantha	190	397	162	123	104	88	123	268	88	449	278	603	684	825	0.80
19	Surendranagar	3258	4728	1083	894	991	4970	4721	3696	3513	4538	4084	4979	4941	3735	3.63
20	Rajkot	618	2708	852	1790	3644	4481	4433	4504	1393	1874	1116	1767	6304	8838	8.59
21	Bhavnagar	112	30	312	848	576	353	596	365	216	169	209	898	927	668	0.65
22	Kachchh	503	2761	331	200	236	2037	60	85	13	14	20	107	111	67	0.07
23	Jamnagar	160	310	60	89	584	220	295	577	146	324	642	769	799	267	0.26
24	Porbandar	0	0	10	17	20	80	491	904	379	96	383	730	744	236	0.23
25	Junagadh	67	377	117	167	468	423	427	684	134	320	332	509	551	591	0.57
26	Amreli	61	33	469	120	963	401	185	513	84	81	114	138	151	118	0.11
	Grand Total	**40591**	**50774**	**34267**	**45436**	**50628**	**69936**	**76821**	**78780**	**82047**	**84071**	**85972**	**91231**	**94930**	**102913**	**100.00**

TABLE-32

FISH AND FISH PRODUCTS EXPORT FROM INDIA AND GUJARAT SINCE 2000-2001 TO 2013-2014

[QTY. IN MT. & VALUE IN CRORE RS.]

[Average Price Realisation]

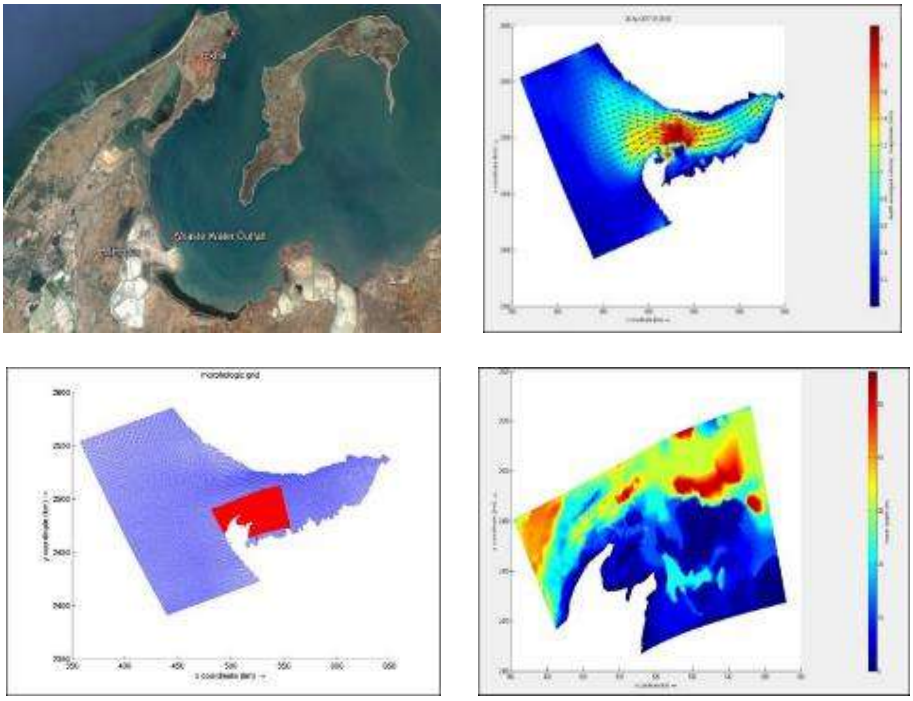
Sr. No.	Year	India			Gujarat			State's Share in India	
		Qty.	Value	Unit Value Rs/Kg	Qty.	Value	Unit Value Rs/Kg	Qty. %	Value %
1	2	3	4	5	6	7	8	9	10
1	2000-01	440473	6443.89	146.29	124159	615.65	49.59	28.19	9.55
2	2001-02	424470	5957.05	140.34	132175	625.72	47.34	31.14	10.50
3	2002-03	467297	6881.31	147.26	134047	760.36	56.72	28.69	11.05
4	2003-04	412017	6091.95	147.86	108386	614.41	56.69	26.31	10.09
5	2004-05	461329	6646.69	144.08	119951	704.59	58.74	26.00	10.60
6	2005-06	512164	7245.30	141.46	136485	934.88	68.50	26.65	12.90
7	2006-07	612641	8363.53	136.52	188166	1264.61	67.21	30.71	15.12
8	2007-08	541701	7620.92	140.68	150727	1141.97	75.76	27.82	14.98
9	2008-09	602835	8607.94	142.79	164725	1485.72	90.19	27.33	17.26
10	2009-10	678436	10048.53	148.11	183870	1838.75	100.00	27.10	18.30
11	2010-11	807063	12825.96	158.92	198297	2156.20	108.75	24.57	16.81
12	2011-12	862021	16597.23	192.54	196850	2533.99	128.73	22.84	15.27
13	2012-13	928216	18856.28	203.15	242057	2929.61	121.03	26.08	15.54
14	2013-14	983756	30213.26	307.12	251920	3658.57	145.23	25.61	12.11

Source : *The Marine Products Export Development Authority kochi India*

TATA CHEMICALS LIMITED

Water Quality Modeling for Treated Waste Water Discharge from Tata Chemicals Limited into Sea (Mithapur Bay), Devbhumi Dwarka, Gujarat

OCTOBER 2017



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Environment for Development

Images clockwise from top left:

1. Marine Outfall Location on google of Mithapur
2. Magnitude and Direction of Peak ebb current in gulf of Kutch
3. Nested grids used in Hydrodynamic Model
4. Bathymetry used in small scale in Okha Model

TATA CHEMICALS LIMITED

Water Quality Modeling for Treated Waste Water Discharge from Tata Chemicals Limited into Sea (Mithapur Bay), Devbhumi Dwarka, Gujarat

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Name of Publication	Water Quality Modeling for Treated Waste Water Discharge from Tata Chemicals Limited into Sea (Mithapur Bay), Devbhumi Dwarka, Gujarat						
Project Number	1728218128	**Issue No.**	02	**Revision No.**	04	**Released**	October, 2017
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1 INTRODUCTION

1.1 Identification of project & project proponent

A part of the over US$ 100 billion Tata Group, Tata Chemicals Limited, is a global company with interests in businesses that focus on LIFE—Living, Industrial and Farm Essentials. The story of the company is about harnessing the fruits of science for goals that go beyond business.

Through its Living Essentials portfolio the company has positively impacted the lives of millions of Indians. Tata Chemicals is the pioneer and market leader in India's branded Iodised salt segment. Extending its portfolio from salt to other food essentials, the Company unveiled India's first national brand of pulses, followed by a range of spices housed under the Tata Sampann brand. Tata Chemicals has been rated as one of the top 10 in Business and Consumer brands across all industry and consumer brand categories in India by Super brands.

The company's Industry Essentials product range provides key ingredients to some of the world's largest manufacturers of glass, detergents and other industrial products. Tata Chemicals currently is the world's second largest producer of soda ash with manufacturing facilities in Asia, Europe, Africa and North America. With its Farming Essentials portfolio, the company has carved a niche in India as an agri-inputs provider. It is a key player in specialty and complex fertilisers and, through its subsidiary Rallis, has a strong position in the crop protection business. The Tata Chemicals Innovation Centre is home to world class R&D capabilities in the emerging areas of nanotechnology and biotechnology. In line with its mission, 'serving society through science', the company is applying its expertise in sciences, to develop high-tech and sustainable products.

Tata Chemicals Limited (TCL) was founded in 1939 and has operated a Soda ash plant at the Mithapur site since 1943. The site is located close to the Arabian Sea as well as the Gulf of Kutch on the western coast of Gujarat. The industrial township of Mithapur is situated 20 km North of Dwarka and 9 km south of the port of Okha on State Highway 25-A. Western Railway's broad gauge line from Mumbai to Okha, passes through Mithapur.

1.2 Purpose of the Report

TCL has proposed expansion of Soda Ash and Cement production capacities and Captive Cogeneration Power Plant within the existing Chemical Complex at Mithapur, District- Devbhumi Dwarka (Gujarat). As per EIA Notification dated 14.09.2006 and subsequent amendments, the proposed expansion of TCL falls in Category 'A', Project Activity S. No. – 4(e) [Soda Ash Industry], 3(b) [Cement Plant] and 1(d) [Thermal Power Plant].

Ministry of Environment, Forest and Climate Change has issued following Terms of References (ToRs) for above proposals:

Expansion of Soda Ash and Captive Power Plant vide ToR letter No. J-11011/140/2016-IA.II(I) dated 02 August 2016 by EAC Industry-II Committee
Expansion of Cement Plant vide ToR letter No. J-11011/66/1999-IA.II(I) dated 10 January 2017 EAC Industry-I Committee

As per Terms of Reference (Specific ToR point no. A-4, additional ToR point no. IV & General ToR Point no. 7-ii), Water quality modeling for Discharge of Treated waste water into Sea (Mithapur Bay) has been conducted by M/s. Kadam Environmental Consultants, Vadodara. The purpose of this report

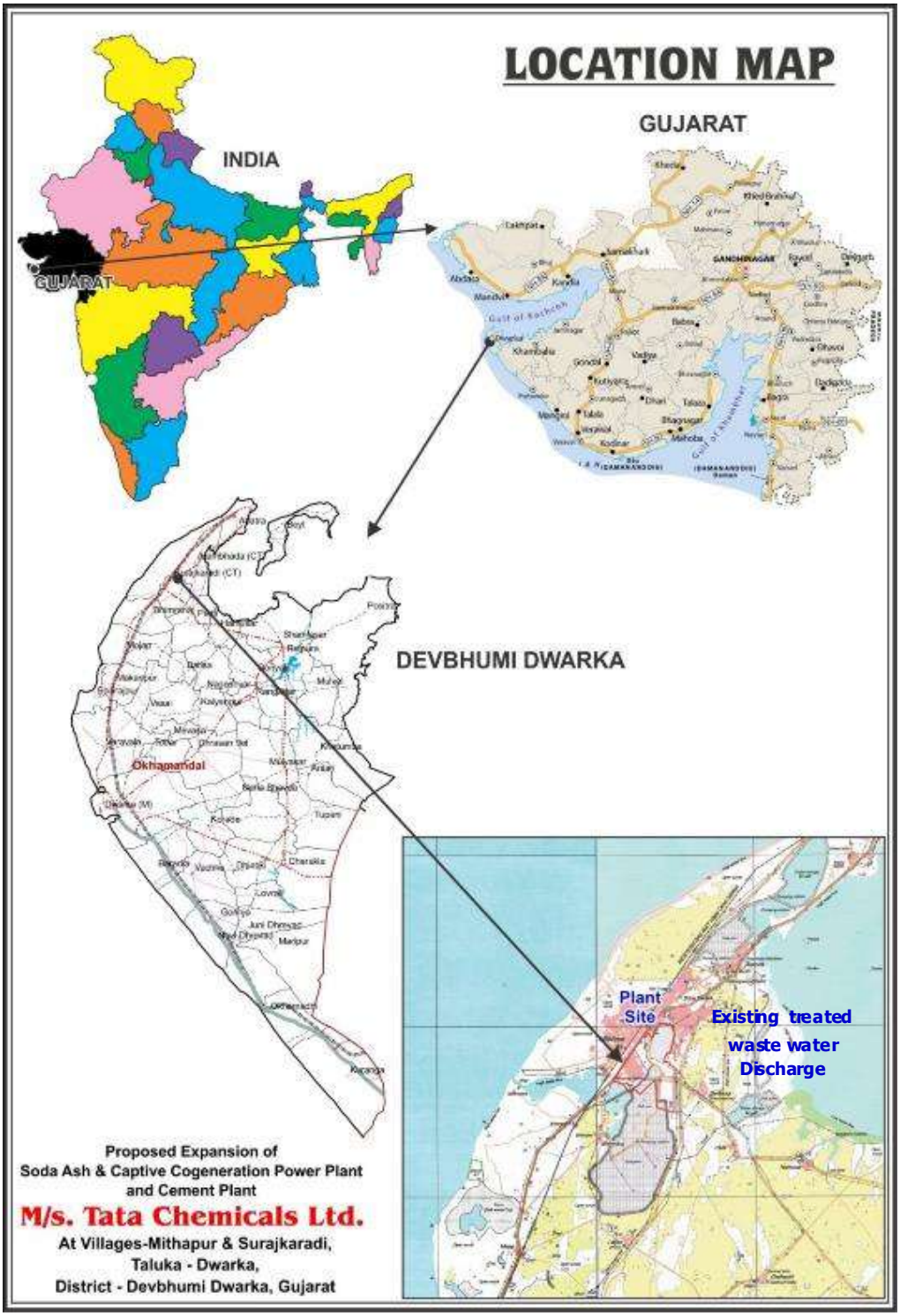
is to assess impact on the quality of receiving water body due to discharge of the treated waste water.

2 MODELLING METHODOLOGY

2.1 Numerical Modelling

The Tata chemicals plant is situated in Mithapur which is situated on a 14.2 km long peninsula which is around 10.2 km wide in the south and 1.7 km wide in the North. It is located at the south west corner or southern starting point of the Gulf of Kutch and surrounded by Arabian Sea in east, west and north direction. Okha port is located on the north-eastern edge of the peninsula. The east face of the peninsula is a curved coast and faces Gulf of Kutch whereas the west coast faces Arabian Sea. The existing waste water disposal site is located on the eastern face of the peninsula and is shown in ***Figure 2-1***. The dispersion of the constituents in the discharged treated waste water is driven by the currents prevalent at location of discharge.

Figure 2-1: Location Map showing location of existing treated waste water discharge



2.2 Hydrodynamic Model

To understand the hydrodynamics of the surrounding area of the existing outfall channel, a numerical model is setup using Delft3D Hydro module. Delft3D software is capable of simulating non-steady flows in relatively shallow water. It incorporates the effects of tides, winds, air pressure, density differences (due to salinity and temperature), waves, turbulence (from a simple constant to the k-ε model) and drying and flooding along with the integrated heat and mass transport solver and is used worldwide for modelling coastal, estuarine and riverine flows.

In the present study only the effect of the tidal hydrodynamics was considered on the dispersion characteristics as this constitutes the worst-case scenario for dispersion of discharged treated waste water. Hence, wind and wave conditions are not imposed on the model domain in this present study.

2.2.1 Basic Governing Equations

The flow module of the Delft3d software solves the Navier stokes equations for an incompressible fluid, under the shallow water and boussinesq assumptions. In the shallow water equation assumption, the depth is assumed to be much smaller than the horizontal scales of flow and bathymetry. This assumption implies that the vertical accelerations are negligible compared to the horizontal accelerations.

The shallow water equations which are the governing equations of the Delft3D model are given below:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+\frac{\omega}{d+\zeta}\frac{\partial u}{\partial \sigma}-fv=-\frac{1}{\rho}P_x+F_x+\frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\nu_V\frac{\partial u}{\partial \sigma}\right) \quad - \quad \text{eq. 2.1}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+\frac{\omega}{d+\zeta}\frac{\partial v}{\partial \sigma}+fu=-\frac{1}{\rho}P_y+F_y+\frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\nu_V\frac{\partial v}{\partial \sigma}\right) \quad - \quad \text{eq. 2.2}$$

$$\frac{\partial \omega}{\partial \sigma}=-\frac{\partial \zeta}{\partial t}-\frac{\partial[(d+\zeta)u]}{\partial x}-\frac{\partial[(d+\zeta)v]}{\partial y}+H(q_{in}-q_{out})+P-E \quad - \quad \text{eq. 2.3}$$

Where u, v, w are the velocity components in the x, y and vertical σ directions respectively. ζ is water level above a given datum, d is depth below the datum. Time is denoted by t. Coriolis parameter is denoted by f. vv is the vertical eddy viscosity.

2.2.2 Transport Equations

In Delft-3D flow, the transport of matter and heat is modelled by an advection diffusion equation in three co-ordinate system. Discharges and sink terms are modelled as sources and sinks. The transport equation is given below:

$$\frac{\partial[(d+\zeta)C]}{\partial t}+\frac{\partial[(d+\zeta)uC]}{\partial x}+\frac{\partial[(d+\zeta)vC]}{\partial y}+\frac{\partial(\omega C)}{\partial \sigma}=$$
$$\left[\frac{\partial}{\partial x}\left(D_x(d+\zeta)\frac{\partial C}{\partial x}\right)+\frac{\partial}{\partial y}\left(D_h(d+\zeta)\frac{\partial C}{\partial y}\right)\right]+\frac{1}{d+\zeta}\frac{\partial}{\partial \sigma}\left[D_v\frac{\partial C}{\partial \sigma}\right]+-\lambda_d(d+\zeta)C+S \quad \text{eq. 2.4}$$

Where λ_d denotes first order decay process. S denotes the source and sink terms per unit area due to discharge or withdrawal.

For the two-dimensional model, the 3 dimensional equations given in eq 2.1 – eq 2.3 reduce to

$$\frac{\partial U}{\partial t}+U\frac{\partial U}{\partial x}+V\frac{\partial U}{\partial y}+fV=-\frac{1}{\rho}P_x+\frac{\tau_{sx}-\tau_{bx}}{\rho(d+\zeta)}+F_x$$

$$\frac{\partial V}{\partial t}+U\frac{\partial V}{\partial x}+V\frac{\partial V}{\partial y}-fU=-\frac{1}{\rho}P_y+\frac{\tau_{sy}-\tau_{by}}{\rho(d+\zeta)}+F_y$$

Where U and V are depth averaged velocity components in two dimensions the bed stresses are given by

$$\frac{\tau_{bx}}{\rho}=\frac{gU\sqrt{U^2+V^2}}{C_{2D}^2}=c_f U\sqrt{U^2+V^2} \qquad \frac{\tau_{by}}{\rho}=\frac{gV\sqrt{U^2+V^2}}{C_{2D}^2}=c_f V\sqrt{U^2+V^2}$$

In the present model study, the given discharge at site is introduced into the hydrodynamic model as source term to study the transport and dispersion of the treated waste water.

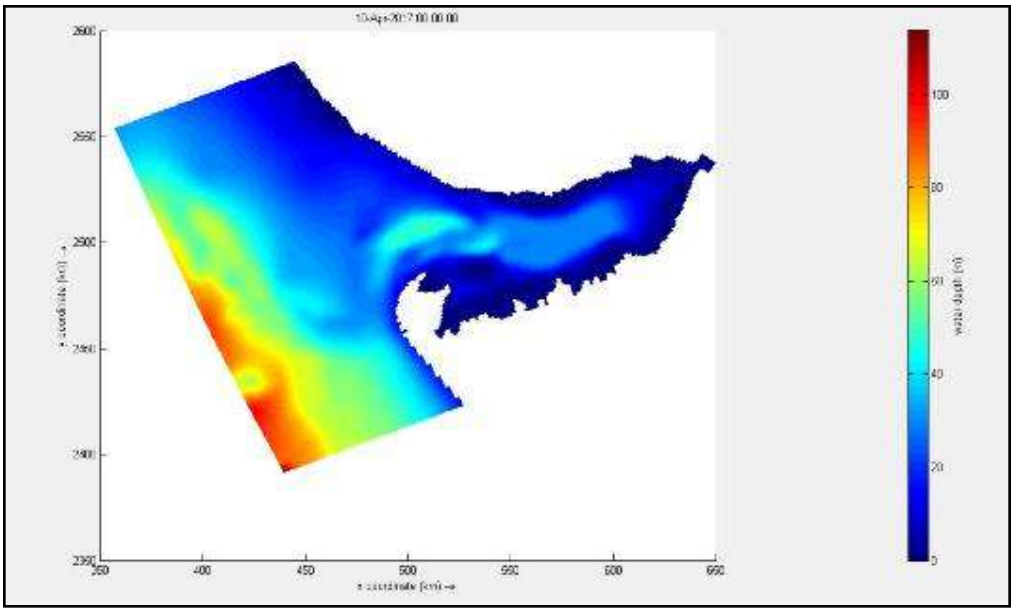
2.3 Model Setup and Calibration

The tidal hydrodynamics model was setup using Delft3D hydro module on curvilinear grids. Nesting technique was adopted wherein a small-scale grid with higher resolution is embedded in large scale model with lower resolution. This methodology helps in reducing computational time without compromising on resolution in the area of interest. Astronomical boundary conditions in the form of astronomical tide components were extracted from TOPEX/Poseidon database and are applied on the boundaries of the large-scale grid covering the entire Gulf of Kutch and the offshore areas. Results from the large-scale model along boundary of the intermediate grid were used as boundary conditions for the small-scale domain. The arrangement of the nested grids is shown in ***Figure 2-2.***

The bathymetry for the large-scale domain and the locations of result extraction are given in ***Figure 2-3***. The bathymetry is generated using digitised naval hydrographic charts covering Okha and Gulf of Kutch. The bathymetry is generated in the model is with respect to MSL which is 2.0 meters above CD at Okha. Maximum grid size in the large-scale model is around 1000 m x 1000 m whereas grid size in the area of interest for small scale grid is around 80 m x 80 m.

Figure 2-2: Nested grids used in Hydrodynamic Modelling

Figure 2-3: Bathymetry of large scale model covering Gulf of Kutch



Results were extracted from the model domain and are used for calibration of the model. Surface elevation variation is extracted from Okha and Sikka in the model domain and the same are compared with the known tide at each location. The model parameters were adjusted until a good match is obtained with the known tide at both the locations. The comparison between model predicted and known tide at both the locations is given in ***Figure 2-4*** and ***Figure 2-5***. It was found that the model results were in good agreement with the site conditions. Peak ebb and flood currents as predicted by

the large-scale model are given in ***Figure 2-6*** and ***Figure 2-7***. The peak ebb current mid of Gulf of Kutch is around 1.8 knots whereas peak flood current is in the order of 2.2 knots.

Figure 2-4: Calibration of Tides at Okha

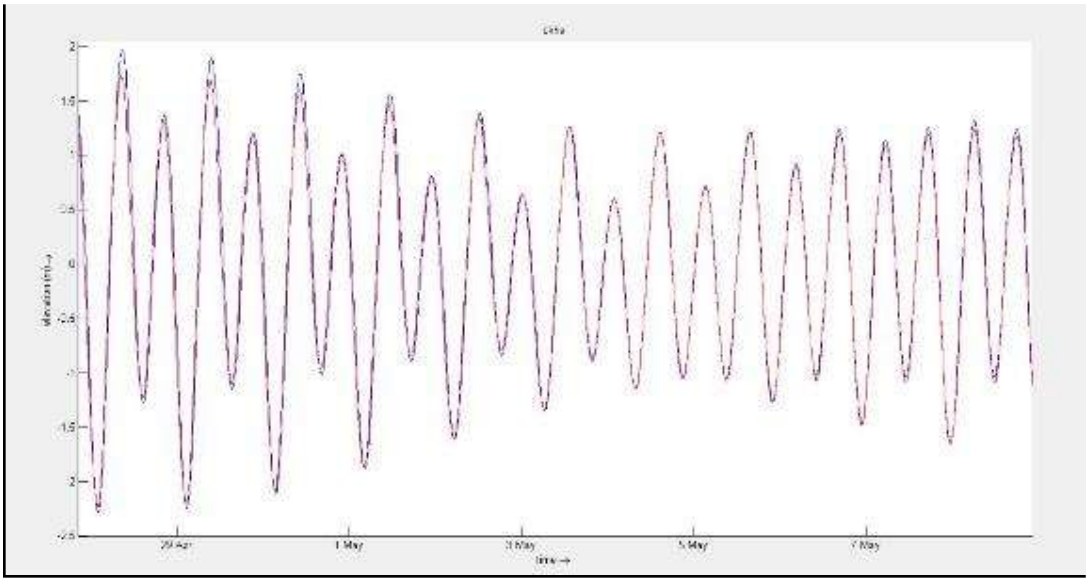


Figure 2-5: Calibration of Tides at Sikka

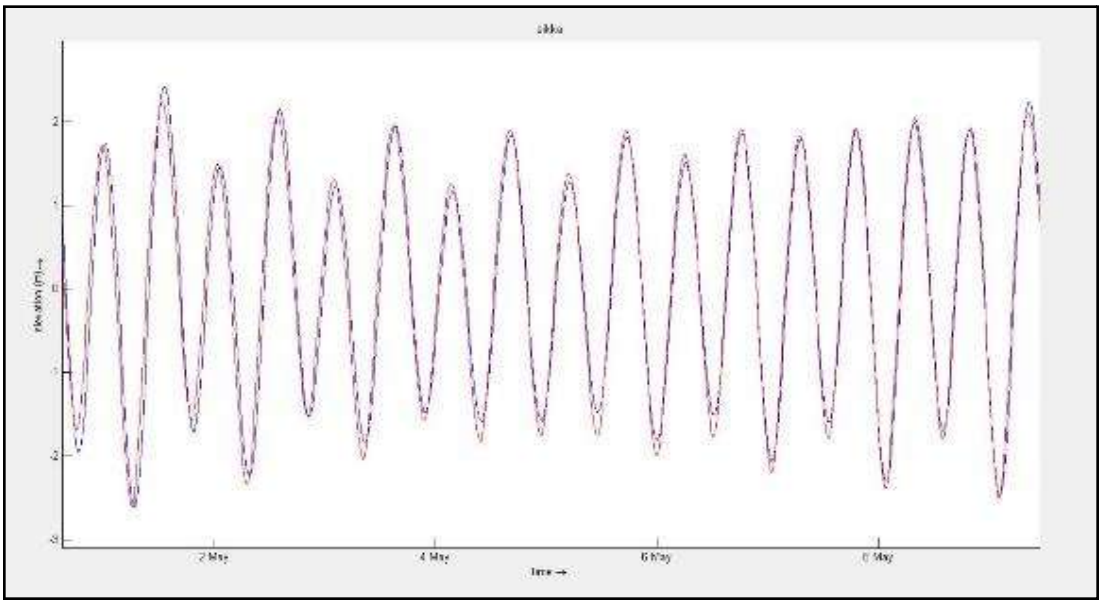


Figure 2-6: Magnitude and direction of peak ebb current in Gulf of Kutch

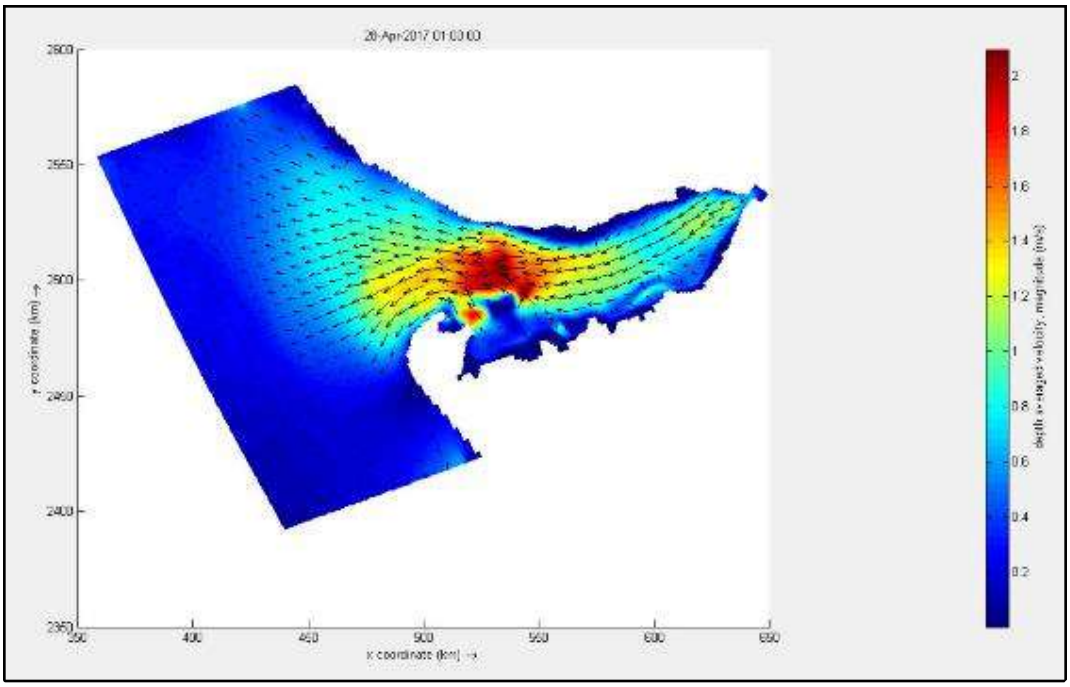
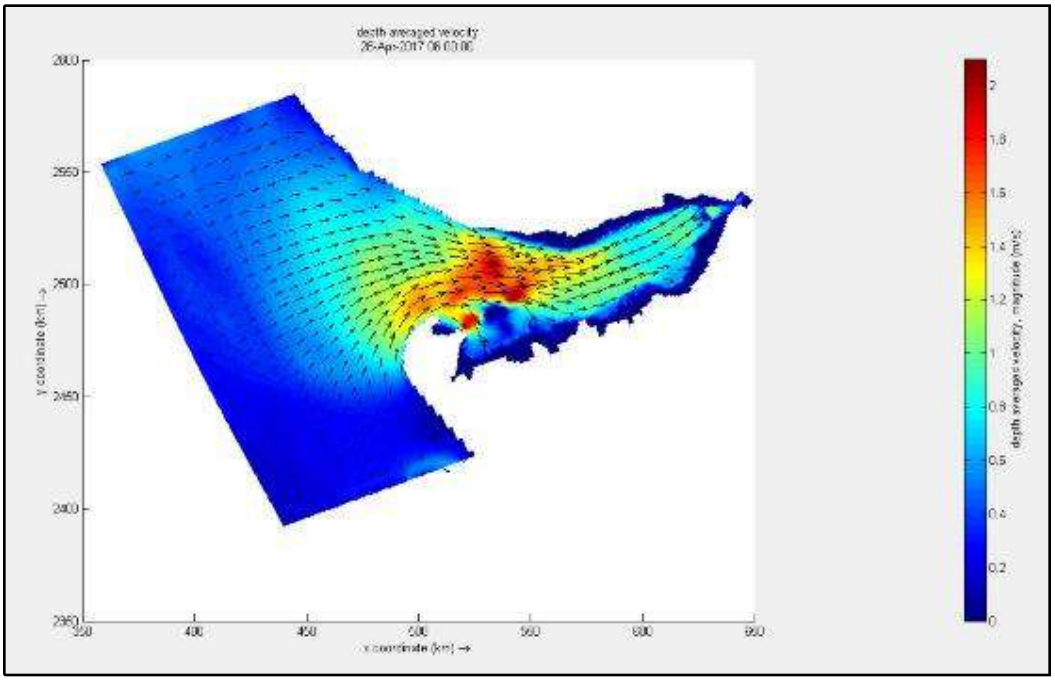


Figure 2-7: Magnitude and direction of Peak flood current in Gulf of Kutch



2.4 Modeling of Flow Regime near the Outfall

This calibrated large-scale model is used for extracting boundary conditions for the small-scale model. The bathymetry and the extent of the small-scale domain are shown in ***Figure 2-8*** and ***Figure 2-9***. The area in the immediate vicinity of the outfall location is marked by shallow depths which are in the order of 0- 2 m with respect to chart datum (CD) and patches with inter tidal zone depths. The Beyt Dwarka Island is located at around 3 km away to the east from the outfall point. The eastern face of the island is marked by deeper patches of water with depths in the order of 6 to 8 meters with respect to CD.

Figure 2-8: Bathymetry used in small scale Okha model

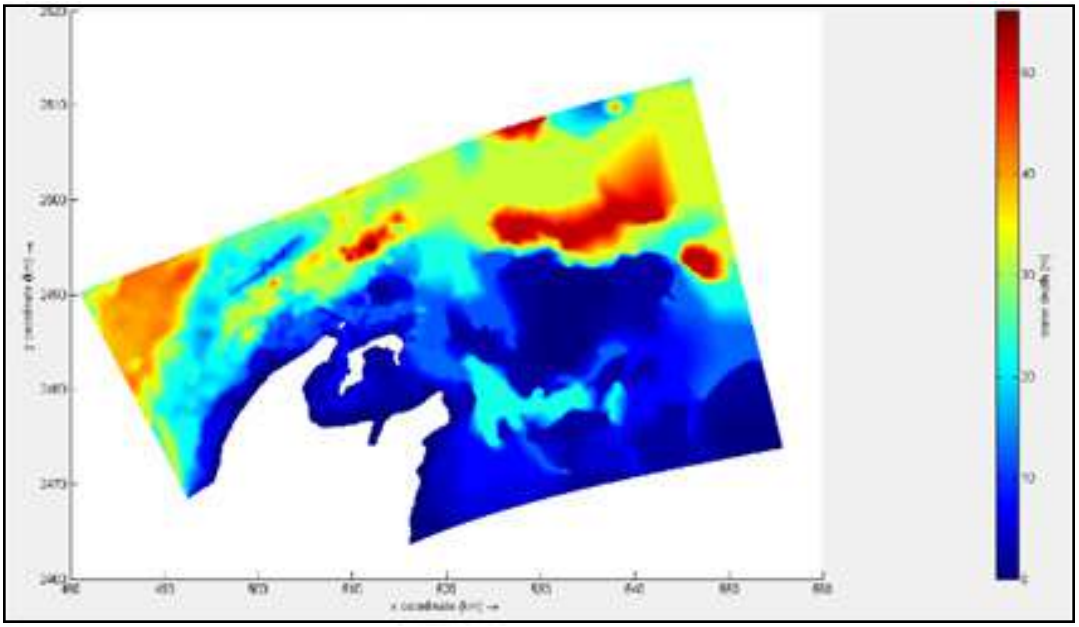
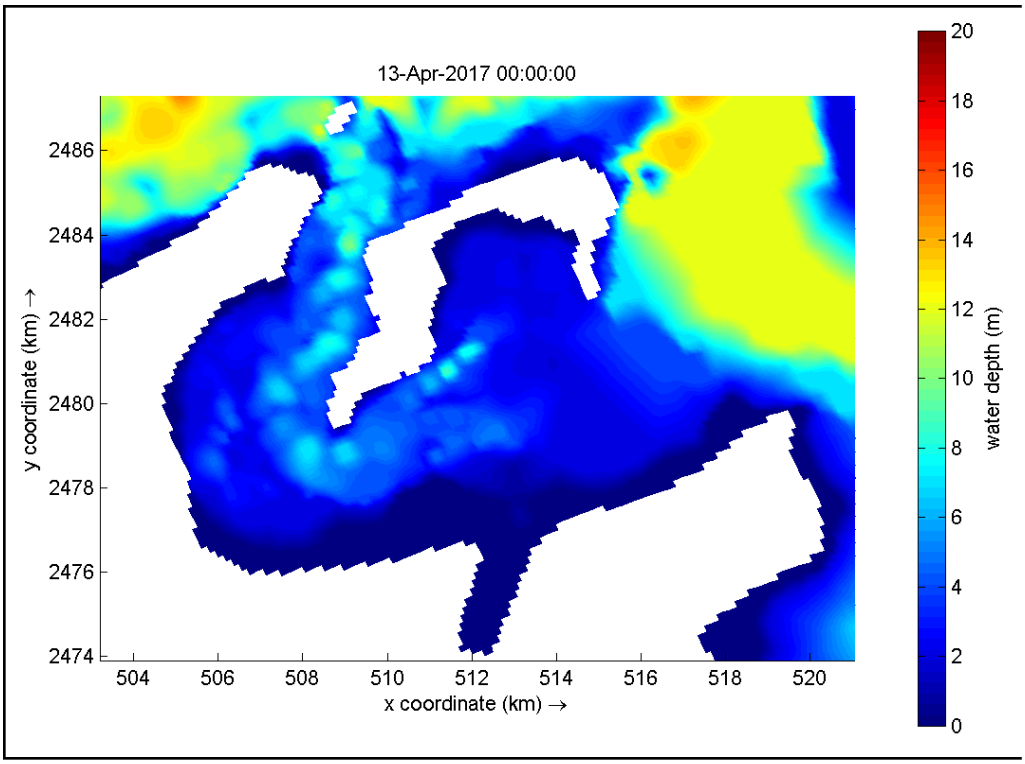


Figure 2-9: Zoomed small scale bathymetry showing Beyt Dwarka and Samiyani islands



The model was run for duration of 1 month to get the flow pattern of the area of interest for both the spring and neap tides. The hourly variation of magnitudes and direction of the currents in the vicinity of the outfall location over one tidal cycle starting from the peak ebb current stage are given in ***Figure 2-10*** and ***Figure 2-23*** to ***Figure 2-24***. The results show that the flow in the vicinity of the outfall is largely influenced by the Beyt Dwarka Island. During the ebb period the movement is along eastern face the Beyt Dwarka Island. The area to the south of Beyt Dwarka Island is a shadow region marked by very low magnitudes of current almost for entire duration of the tidal cycle. This effectively makes the flow around the island to behave like two streams flowing on east and west faces of the island and joining in the area between Okha headland and the Samiyani Island. The magnitudes of the currents during peak ebb in the area between the outfall location and west face of the Beyt Dwarka island is in the order of 1.7 knots in the north-west direction.

During flood current, the reverse pattern is observed wherein the flow enters the area of interest through the gap between Okha headland and Samiyani Island and is divided into two streams, one along the west face of the island and another along the east face of the island. The magnitude of currents during peak flood is around 1.4 knots between the outfall location and the west face of the island in the south-east direction.

Figure 2-10: Magnitude and direction of current during high tide in the area of interest

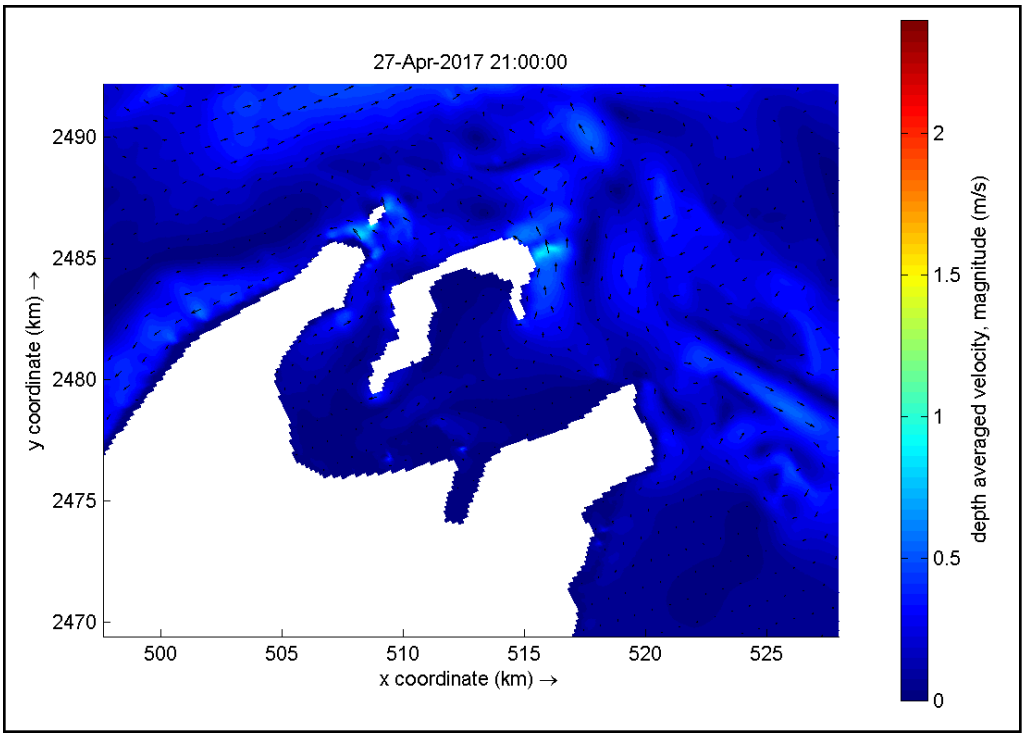


Figure 2-11: Magnitude and direction of current one hour after high tide

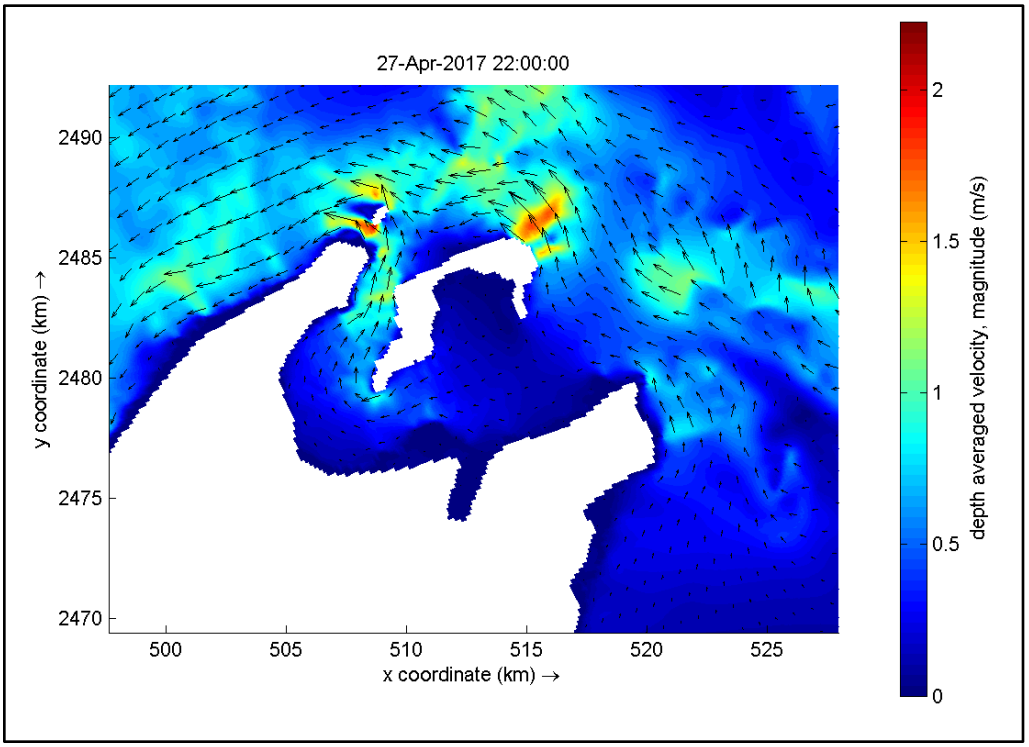


Figure 2-12: Magnitude and direction of current two hours after high tide

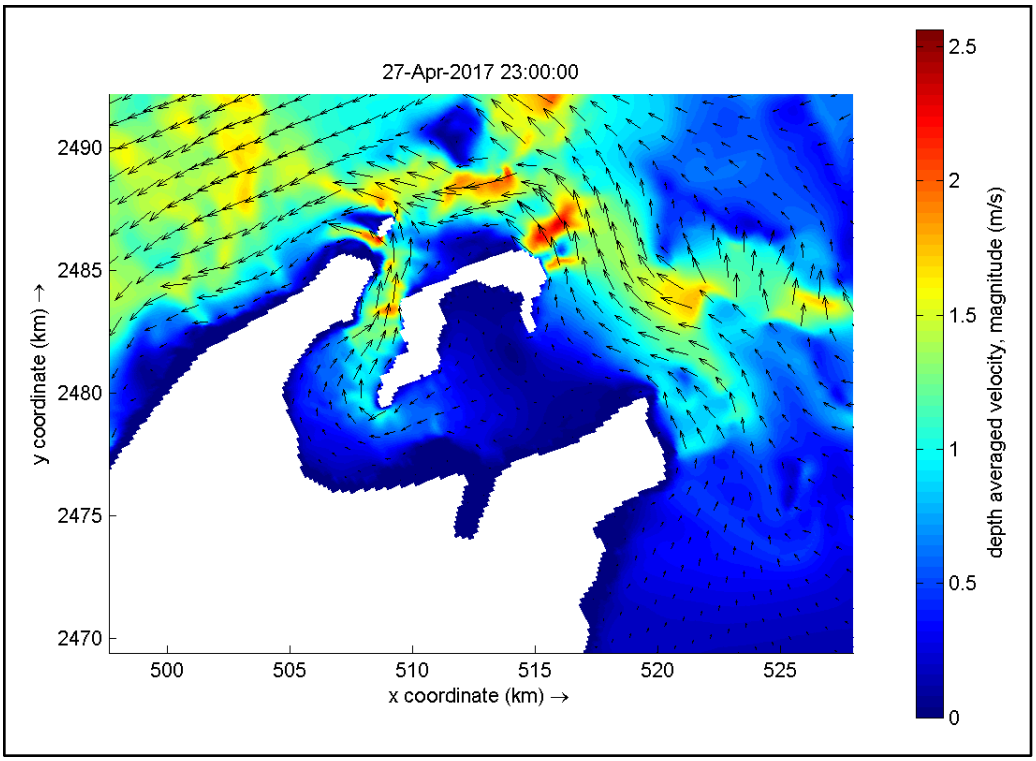


Figure 2-13: Magnitude and direction of current three hours after high tide

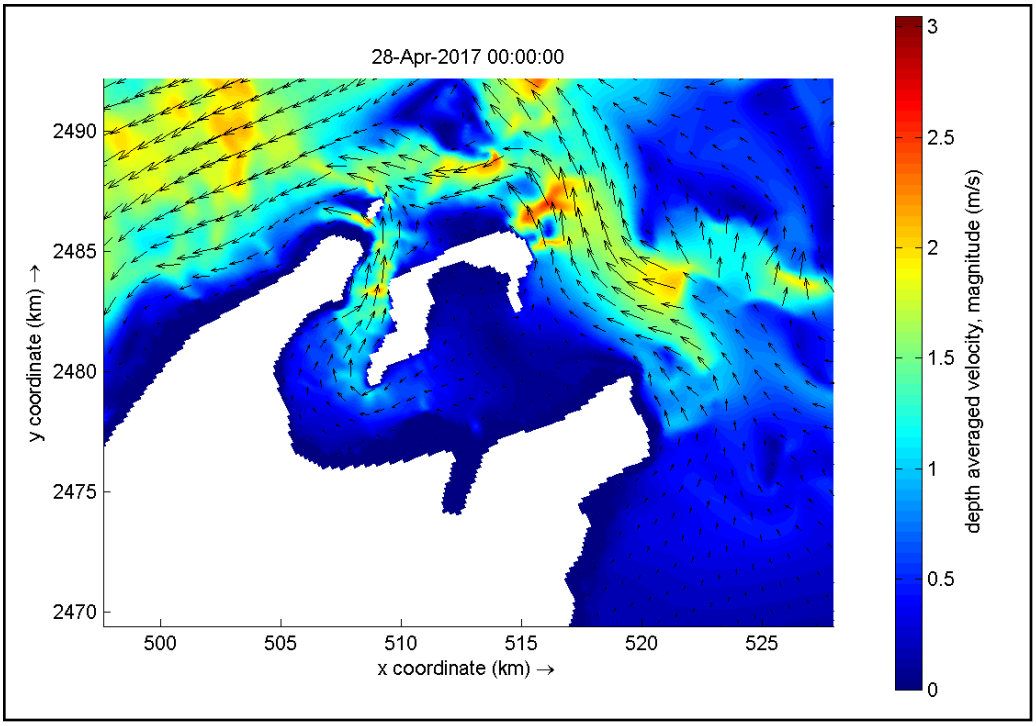


Figure 2-14: Magnitude and direction of current four hours after high tide

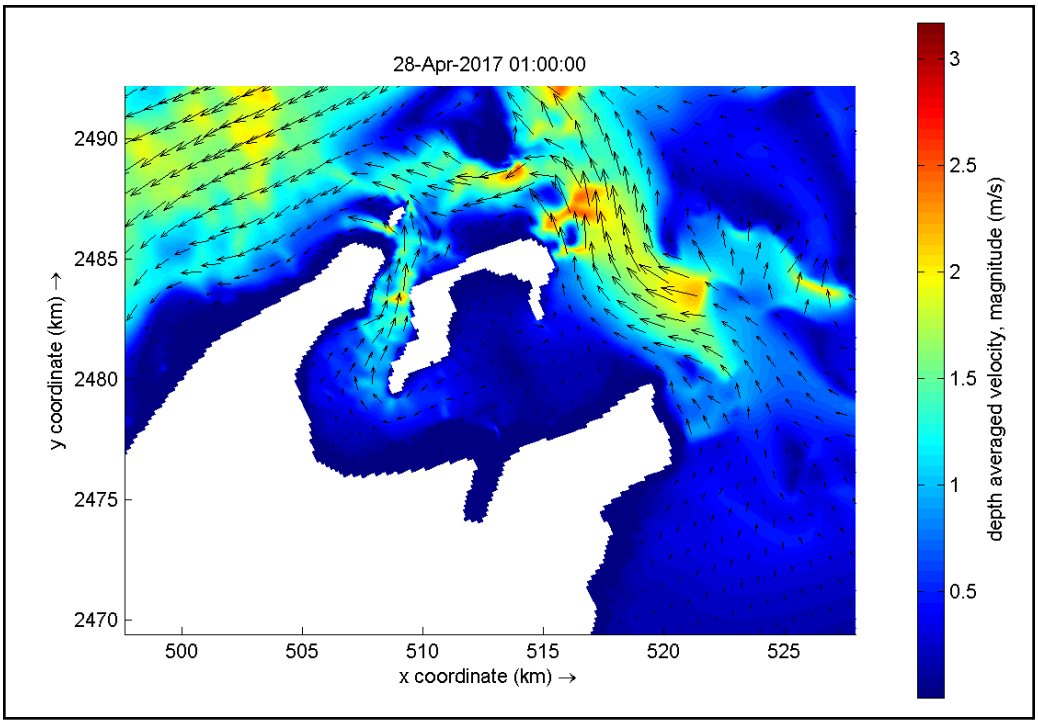


Figure 2-15: Magnitude and direction of current five hours after high tide

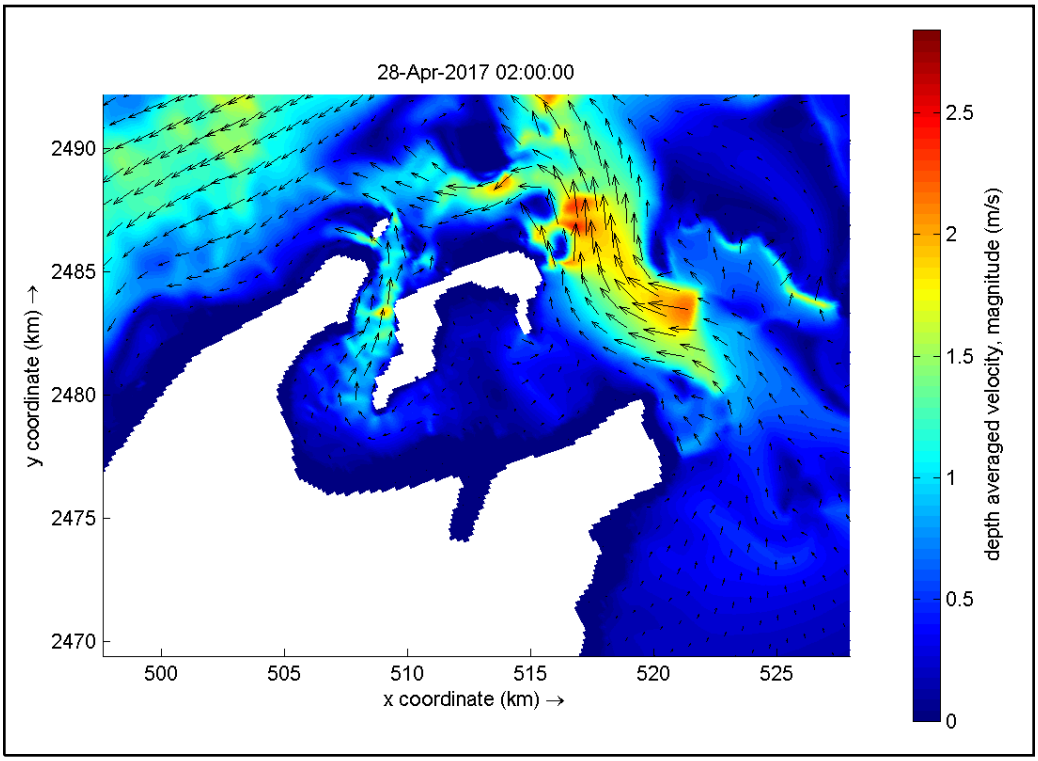


Figure 2-16: Magnitude and direction of current six hours after high tide

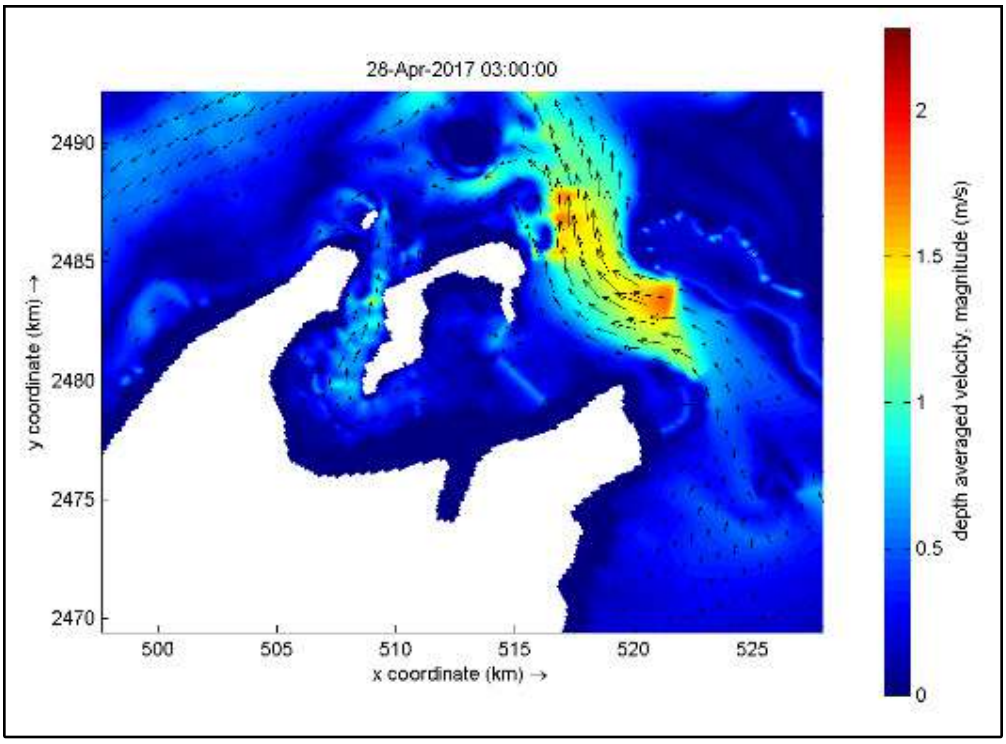


Figure 2-17: Magnitude and direction of current seven hours after high tide

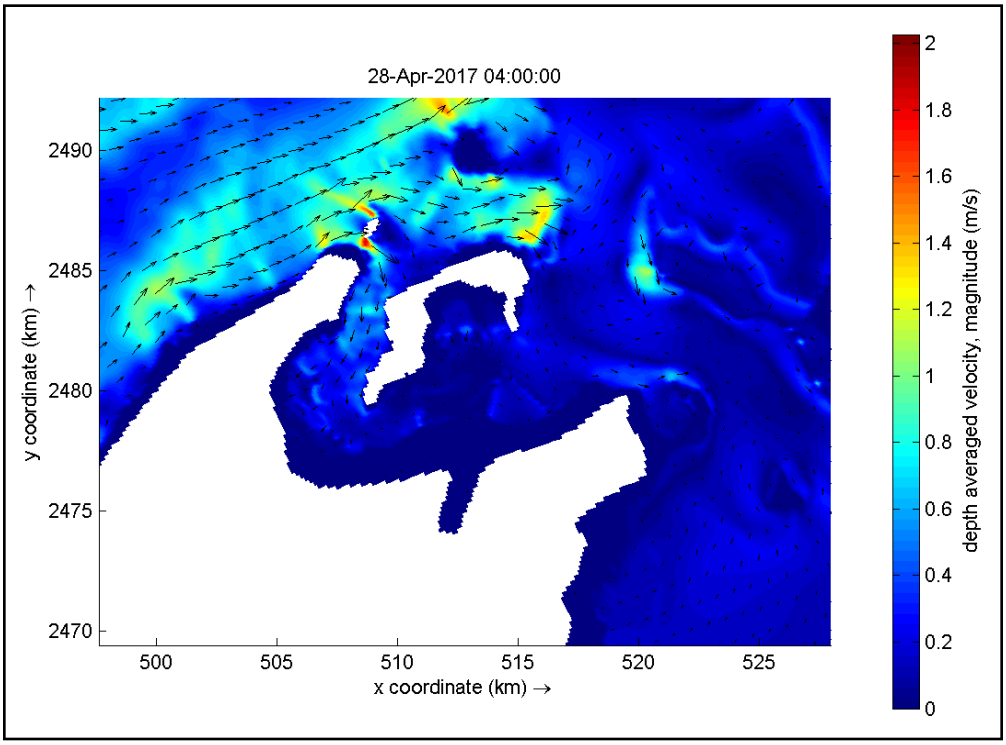


Figure 2-18: Magnitude and direction of current eight hours after high tide

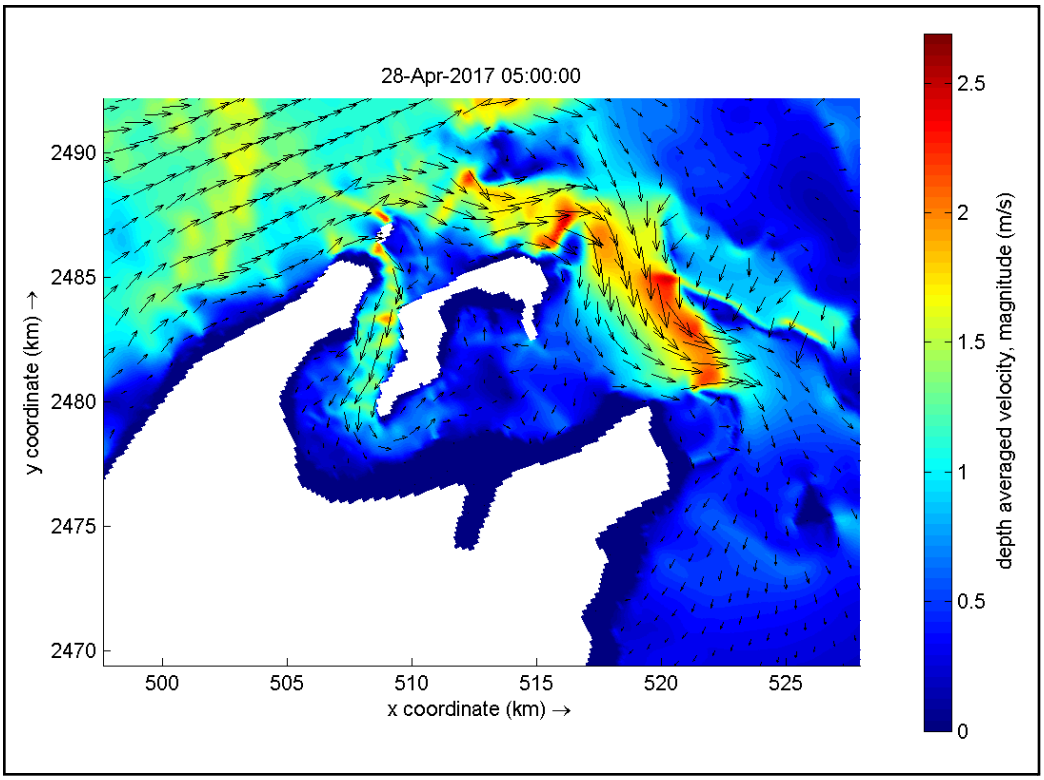


Figure 2-19: Magnitude and direction of current nine hours after high tide

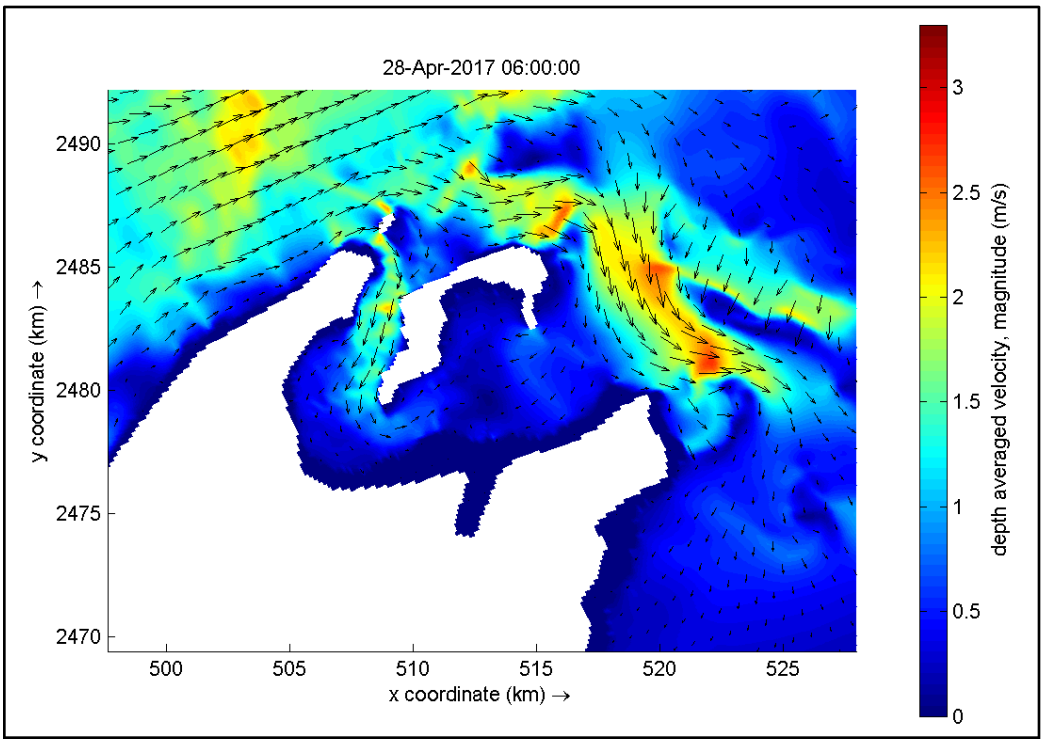


Figure 2-20: Magnitude and direction of current ten hours after high tide

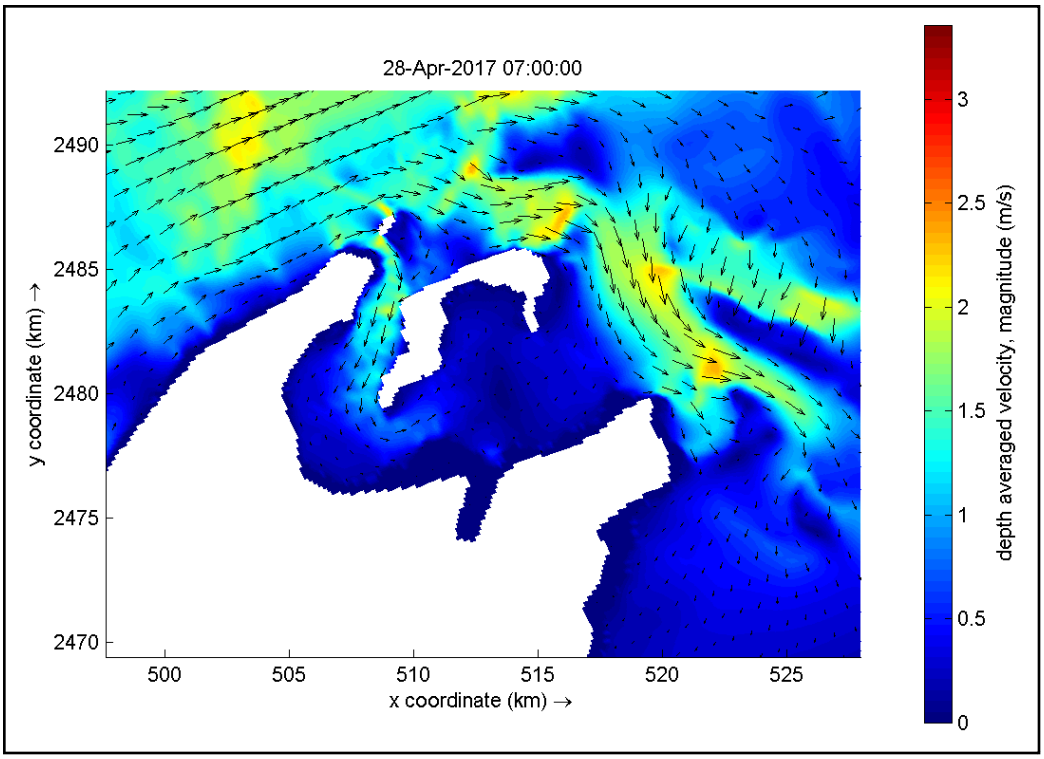


Figure 2-21: Magnitude and direction of current eleven hours after high tide

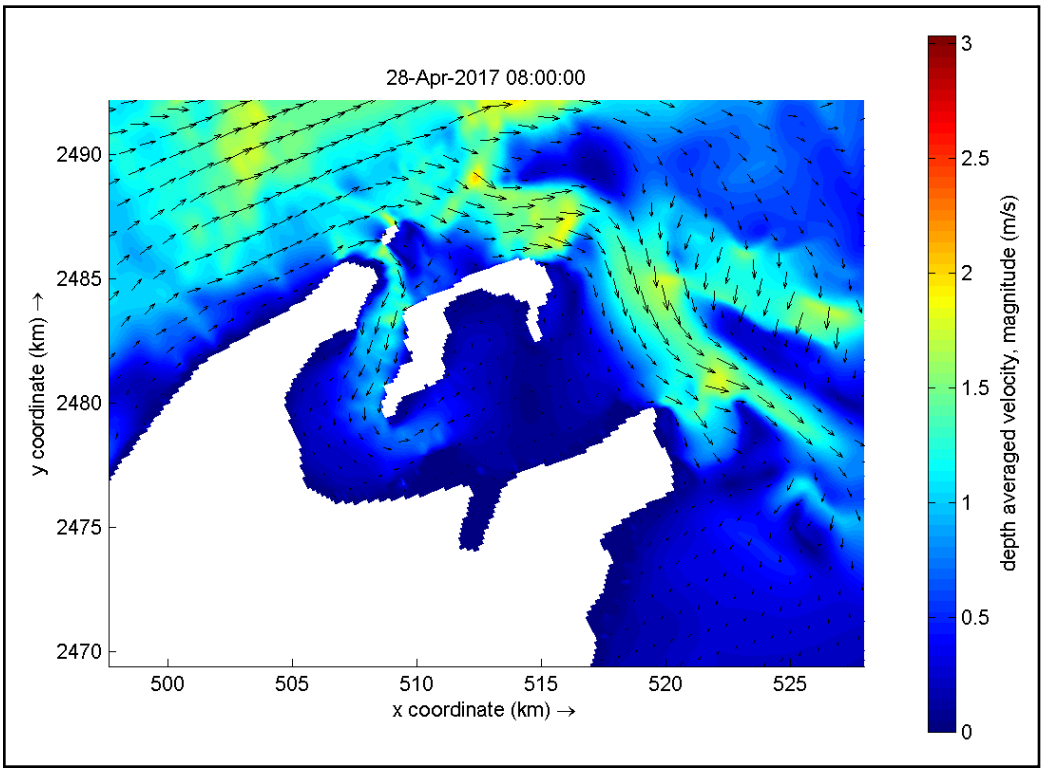


Figure 2-22: Magnitude and direction of current twelve hours after high tide

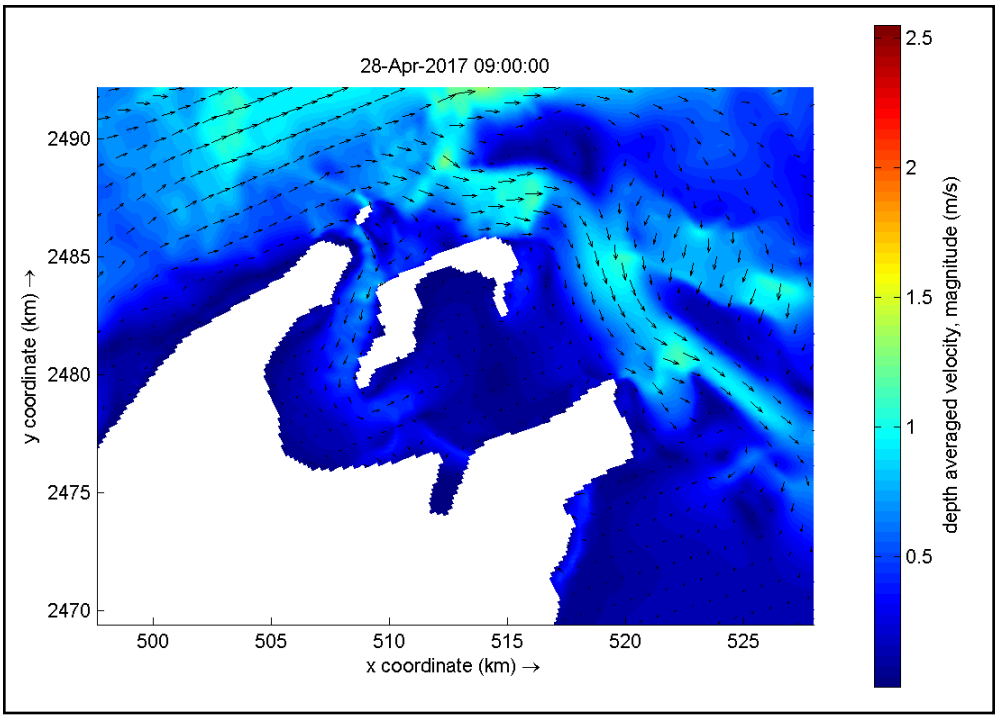


Figure 2-23: Magnitude and direction of current thirteen hours after high tide

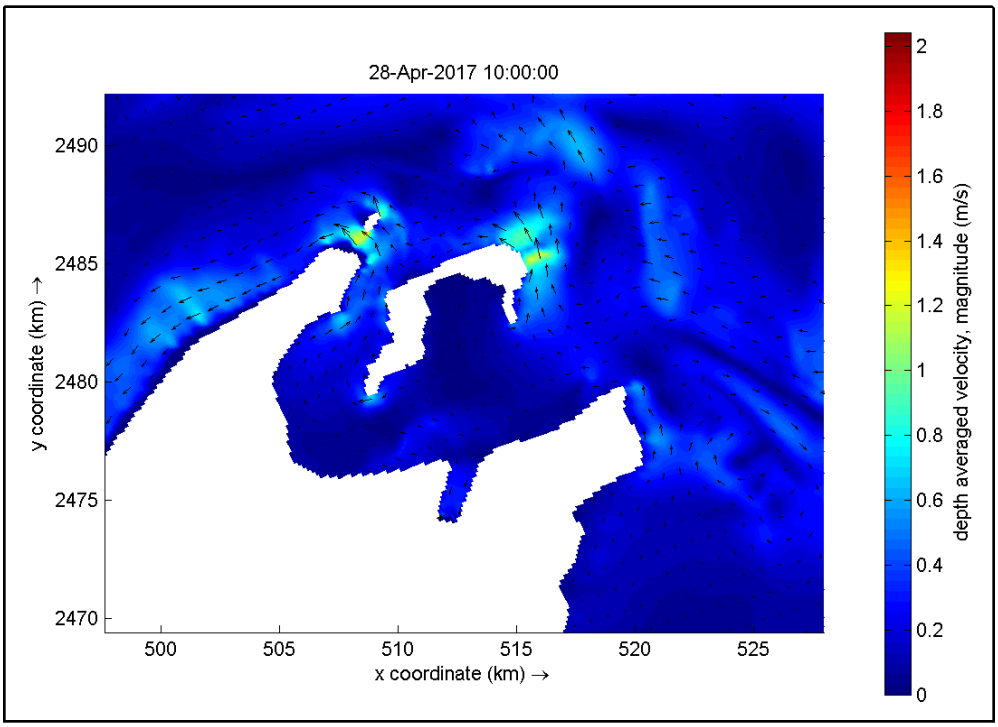
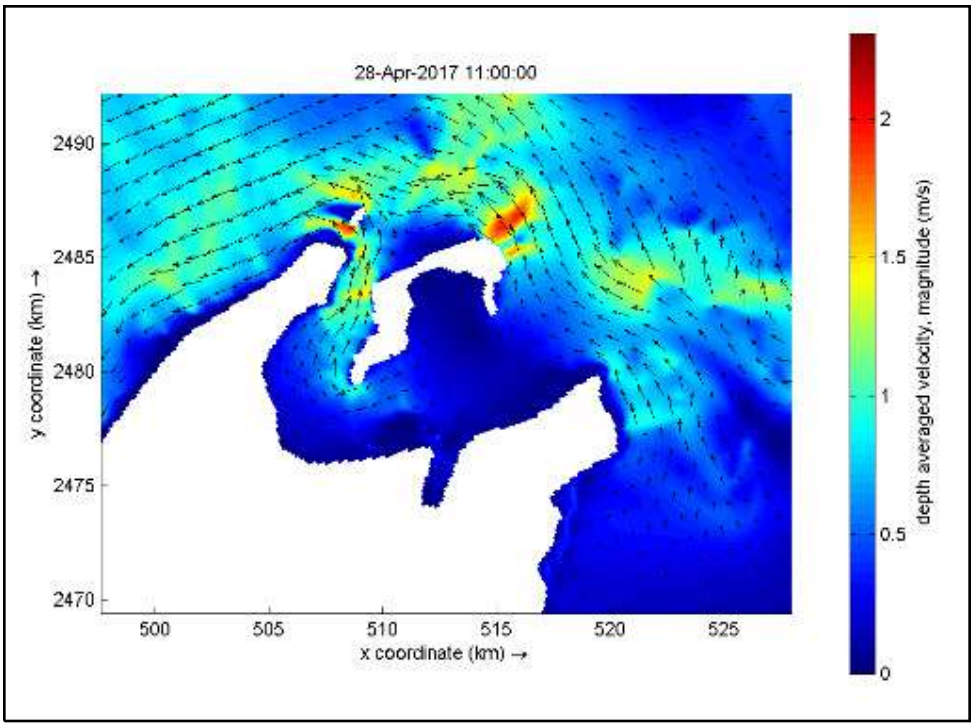


Figure 2-24: Magnitude and direction of current fourteen hours after high tide



3 DISPERSION OF TREATED WASTEWATER

3.1 Characteristics of Treated Waste Water

TCL's Chemical complex has implemented integrated waste management system for reuse and recycling of waste streams and utilizes sea water for its cooling requirements. Treated waste water generated from soda ash unit, spent cooling sea water and other streams from chemical complex are discharged into sea through a single outlet as per prescribed norms. Following are the prescribed GPCB norms for treated waste water (B) and observed characteristics of the treated waste water (C) at the site.

A. Quantity of treated waste water – 2,40,000 m^3/day

Table 3-1: Details of treated waste water (average quantity in m^3/day)

S. No.	Treated wastewater	Existing Limit	Proposed (Additional)	Total after expansion
1	Industrial treated wastewater	240,000	Nil	240,000
2	Domestic waste water	2,400	Nil	2,400

B. Prescribed GPCB norms of treated waste water

Sr. No	Parameters	Prescribed norms
1	pH	6.5 -9.5
2	Temperature	40 ^{0}C
3	Colour (pt. co.scale) in units	100 units
4	Suspended Solids	500 mg/l
5	Oil and Grease	2 mg/l
6	Ammonical Nitrogen	5 mg/l
7	Bio Assay Test	90% Survival of the fish after 96 hours in 100% treated waste water

C. Observed characteristics of the Treated Waste Water

Sr. No	Parameters	Observed values (Average 2016-17)
1	pH	8.3
2	Temperature	29 ^{0}C (winter)
3	Temperature	31 ^{0}C (summer)
4	Suspended Solids	164 mg/l
5	Oil and Grease	0.4 mg/l
6	Ammonical Nitrogen	2.88 mg/l

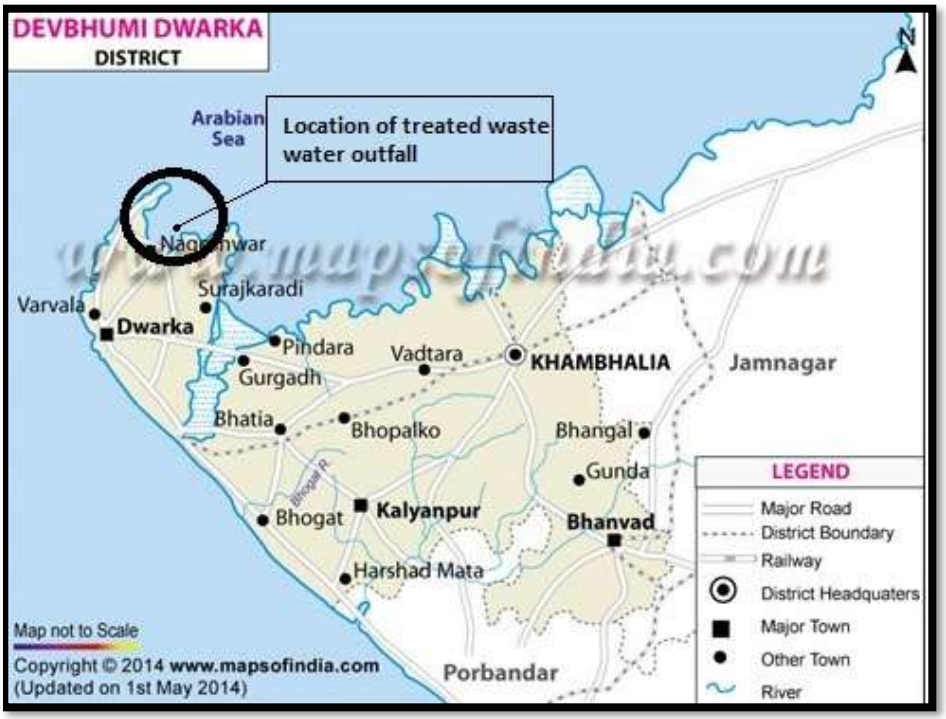
The calibrated hydrodynamic model is introduced with treated waste water in the model domain with both prescribed and observed characteristics as mentioned above. The treated waste water discharge is introduced in the model as source term with continuous discharge of 240000/24/60/60 = 2.778 m^3/sec.

Dispersion of the temperature, suspended solids and Ammonia were studied as part of the study. As per GPCB norms the prescribed oil and grease concentration levels are around 2 mg/l and since the observed oil and grease concentration values in the outfall are 5 times lesser than the allowable quantities, oil and grease is not considered as part of the study.

Considering the existing location of treated waste water, the back-ground concentrations for suspended sediments and ammonia are taken as 0 mg/l. The background temperature taken as spatially and temporally constant value and is kept at 24 °C, so that the effect of the treated waste water temperature on the surrounding waters can be isolated. The simulation was run for duration of one month thereby effectively covering two spring tides and two neap tide periods and is thus a sufficient period to analyse the changes in the surrounding area due to the outfall discharge.

3.2 Location of Release

In the present study existing location (22°24'32.11" N; 69°03'33.36" E) of treated water discharge in the Mithapur Bay has been examined for water quality modelling in surrounding area.



4 RESULTS AND DISCUSSIONS

4.1 Current observation at Treated waste water Discharge Location

To understand the behaviour of the treated waste water discharged into the sea, results were analysed for neap tide and spring tide. The magnitude of current observed at the discharge location (22°24'32.11" N; 69°03'33.36" E) is given in ***Figure 4-1***. The peak average magnitudes of currents are in the order of 0.33 m/sec and 0.27 m/sec during spring tides and 0.15 m/sec and 0.22 m/sec during neap tides. The next sections discuss the behaviour of the discharge during neap and spring periods.

4.2 Study on Temperature variation due to Discharge of Treated Waste Water

The discharged treated waste water is introduced as a source term in the numerical model and the advection and dispersion of heat is modelled as per the equation 2.4. The study considered only the advection and diffusion of heat and neglected the exchange of heat at the air water interface due to wind so that the results obtained enable one to identify the locations where temperature might increase and the indicate the maximum possible temperature which can occur there. The runs conducted in this study can be considered to represent the scenario of winter season wherein the difference between the discharge temperature and the ambient temperature is maximum which can result in the maximum possible temperature difference in the vicinity of the discharge location.

Results from simulations for the prescribed discharge treated waste water concentrations which cater to the case of maximum possible increase in temperature were plotted for various stages of each tide cycle. Plots showing variation of temperature were given for the high tide, peak ebb current, low water, peak flood current and high tide of the next tidal cycle. In addition, results from the model over the entire simulation period i.e. one month for both prescribed and observed treated waste water concentrations were extracted from various locations in the vicinity of the discharge location to understand the behaviour of discharged treated waste water into the water. The points of data extraction are shown in ***Figure 4-12***. The point P represent the discharge location and the points B, C, D in the figure represent the locations in the East, North and South directions respectively at a distance 300 m from the location of discharge. The points B1, C1, D1 in the figure represent the locations in the East, North and South directions respectively at a distance 600 m from the location of discharge. The points B2, C2, D2 in the figure represent the locations in the East, North and South directions respectively at a distance 1000 m from the location of discharge.

The results show that the increase in temperature greater than 0.3 °C due to the discharge of treated waste water is confined to the region parallel to the shore. The spread of the temperature plume is very short in the cross-shore direction when compared to the along shore direction. Results show that during the flood current the temperature plume advects in the southern direction. During the ebb tide, as the current magnitude is less than that of flood tide, the discharge plume undergoes more dispersion when compared to during flood tide. Hence the shift in the plume is more in the southern direction when compared to northern direction during a tide cycle.

The results show that the temperature increase in the surrounding areas due to the discharge plume is limited as described below:

- The period of high tide is shown in ***Figure 4-2*** and ***Figure 4-7*** for the spring and neap periods respectively. During spring tide, it can be seen that the rise in temperature due to the treated waste water is limited to 0.3 °C in the vicinity of discharge location and a maximum rise of 0.4 °C is observed near the shore at a distance of 1800 m – 2000 m in the south and southeast direction. During the neap tide, the highest temperature increase around 0.45 °C is observed in the vicinity of the discharge location and lesser temperature in the order of 0.35 °C - 0.4 °C increase is observed near the shore around in the south and south east directions spread over a distance of 1000 m.
- The period of peak ebb current is shown in ***Figure 4-3*** and ***Figure 4-8*** for the spring and neap periods respectively. During spring tide, it can be seen that the rise in temperature due to the treated waste water is limited to 0.4 °C in the vicinity of discharge location which rapidly to reduces 0.3 °C which spreads over an area extending from 500 meters to the north of discharge location to 2200 m to the south of the discharge location. During the neap tide, the higher temperatures increase around 0.5 °C is observed in the vicinity of the discharge location and lesser temperature increase around 0.4 °C near in the north and north-west directions near the shore spread over a distance of 800 m.
- The period of low tide level is shown in ***Figure 4-4*** and ***Figure 4-9*** for the spring and neap periods respectively. During spring tide, it can be seen that the rise in temperature due to the treated waste water is limited to 0.6 °C in the vicinity of discharge location covering a 400 m diameter circular area further, a 0.3 °C increase in temperature is along the shore and extends from 4000m north of the discharge location to 2000 m south of the discharge location. During the neap tide, a temperature increase of around 0.5 °C is observed in the vicinity of the discharge location and the plume extends in the north direction up to a distance of 2200 m with lesser temperature increase of around 0.4 °C.
- The period of peak flood current is shown in ***Figure 4-5*** and ***Figure 4-10*** for the spring and neap periods respectively. During spring tide, it can be seen that the maximum rise in temperature due to the treated waste water is around 0.6 °C and spreads up to a distance of 400 meters in the south-west direction. This 0.3 °C increase in temperature is along the shore and extends from 4000 m north of the discharge location to 2000 m south of the discharge location. During the neap tide, it can be seen that the maximum rise in temperature due to the treated waste water is around 0.55 °C and occurs at a distance of 1000 m in the south direction.
- At the end of the tidal cycle i.e. at high water as shown in ***Figure 4-6*** and ***Figure 4-11***, it can be seen that the patterns are nearly similar to the same as given in ***Figure 4-2*** and ***Figure 4-7*** and the temperature increase values are nearly same. This means that the treated waste water caused changes in the surrounding areas are not accruing in time but are transient in nature.

It can also be seen that during the entire tide cycles for both the spring and neap tides, the temperature change near the Beyt Dwarka Island and the Okha harbour are less than 0.05 °C which can be considered negligible.

4.2.1 Temporal variation of temperature at different distances from the outfall location for GPCB prescribed conditions and observed conditions

Prescribed characteristics

The variation of the temperature for the GPCB prescribed characteristics of the treated waste water are given in ***Figure 4-13 to Figure 4-15*** over the entire simulation period at locations along the South, North and East directions at distances 300 m, 600 m, 1000 m from the discharge location. It was observed that the temperature increase is dissipated in the eastern direction very rapidly, i.e.

towards the Beyt Dwarka Island the peak change in temperature is 0.6 °C, 0.3 °C and 0.2 °C at 300 meters, 600 meters and 1000 meters respectively. In the North direction the peak change in temperature are 0.7 °C, 0.5 °C and 0.5 °C at 300 meters, 600 meters and 1000 meters respectively. In the south direction the peak change in temperature are 1.1 °C, 0.9 °C and 0.7 °C at 300 meters, 600 meters and 1000 meters respectively. From the plots, it can also be seen that there is no cumulative increase in temperature over period of one month which implies that the area in the vicinity of the treated waste water discharge is marked by good flushing characteristics.

Observed Characteristics

The variation of the temperature for the observed characteristics of the treated waste water are given in ***Figure 4-16*** to ***Figure 4-18*** over the entire simulation period at locations along the South, North and East directions at distances 300 m, 600 m, 1000 m from the discharge location. Results show that for the treated waste water released with observed characteristics, the increase in temperature at a distance of 300 m from the treated waste water discharge location is around 0.33 °C in the south direction, 0.18 °C in the north direction and 0.15 °C in the east direction. At a distance of 600 m from the treated waste water discharge location, the increase in temperature is around 0.28 °C in the south direction, 0.14 °C in the north direction and 0.09 °C in the east direction. At a distance of 1000 m from the treated waste water discharge location, the increase in temperature is around 0.23 °C in the south direction, 0.12 °C in the north direction and 0.05 °C in the east direction.

Figure 4-1: Variation of Current near outfall location

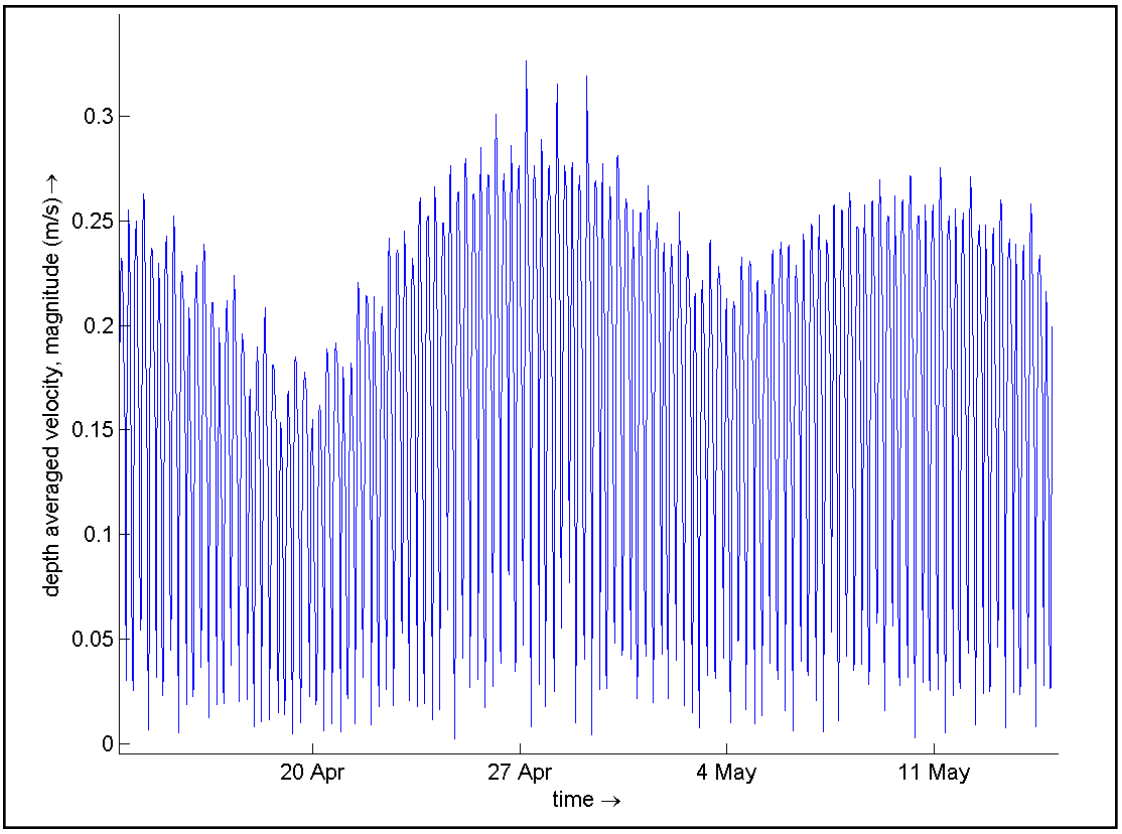


Figure 4-2: Temperature distribution at high water (start of spring tide cycle)

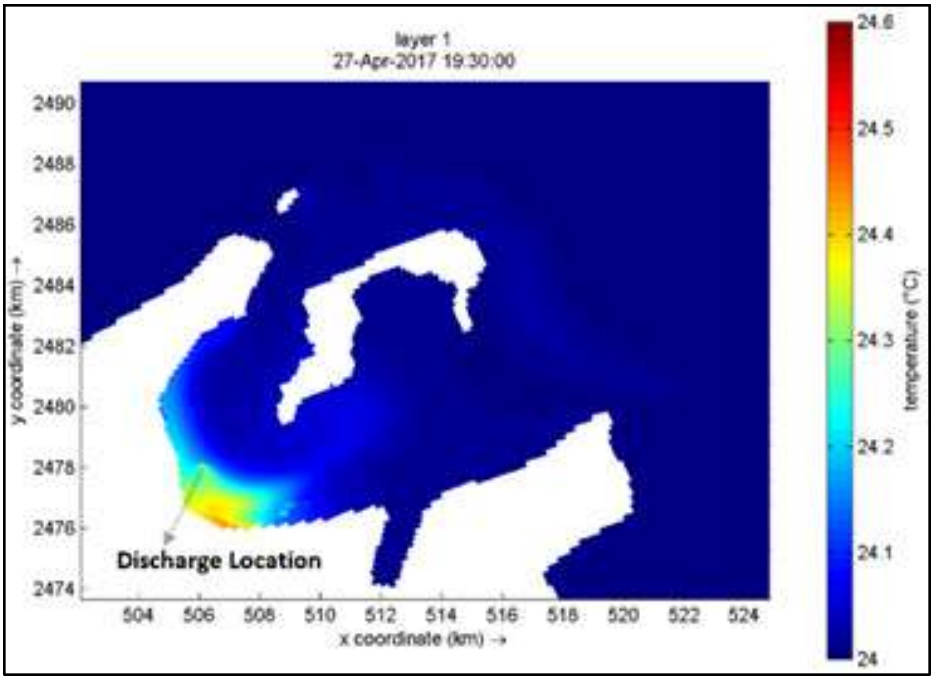


Figure 4-3: Temperature distribution during peak ebb current (spring tide cyde)

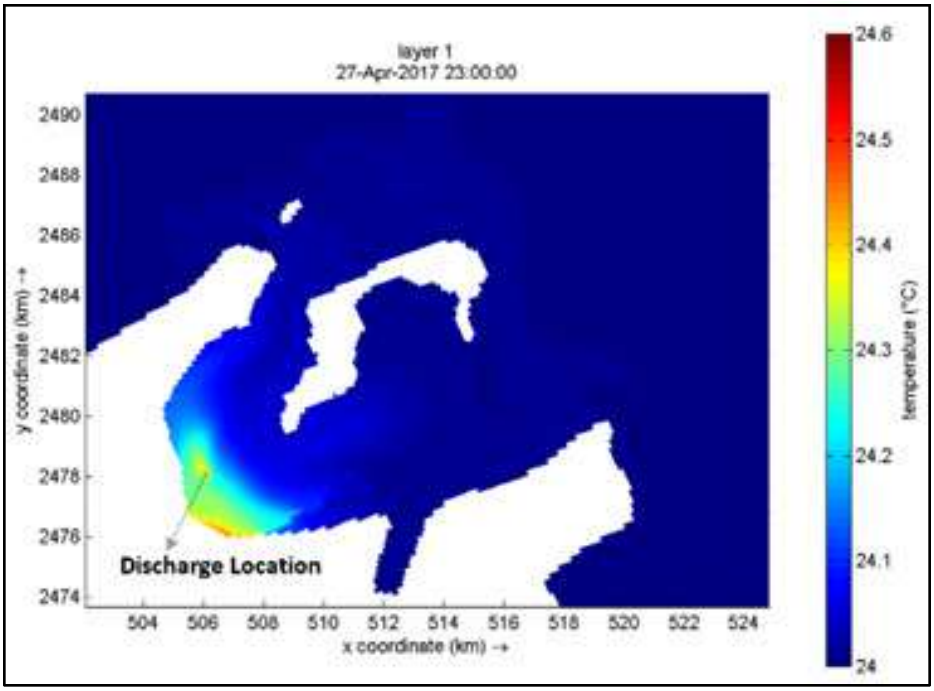


Figure 4-4: Temperature distribution during low tide (spring tide cycle)

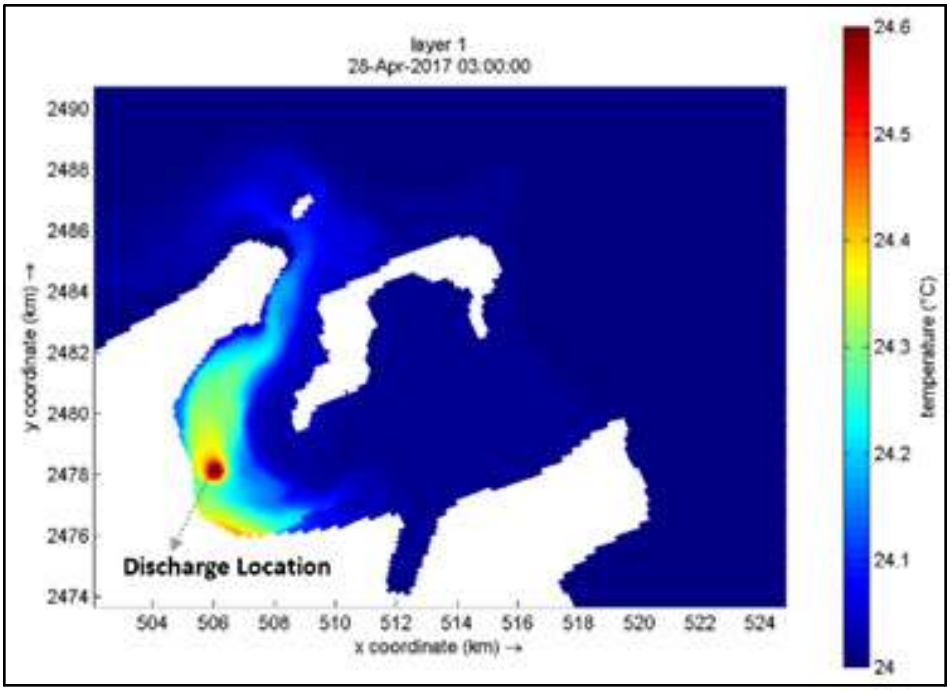


Figure 4-5: Temperature distribution during peak flood current (spring tide cycle)

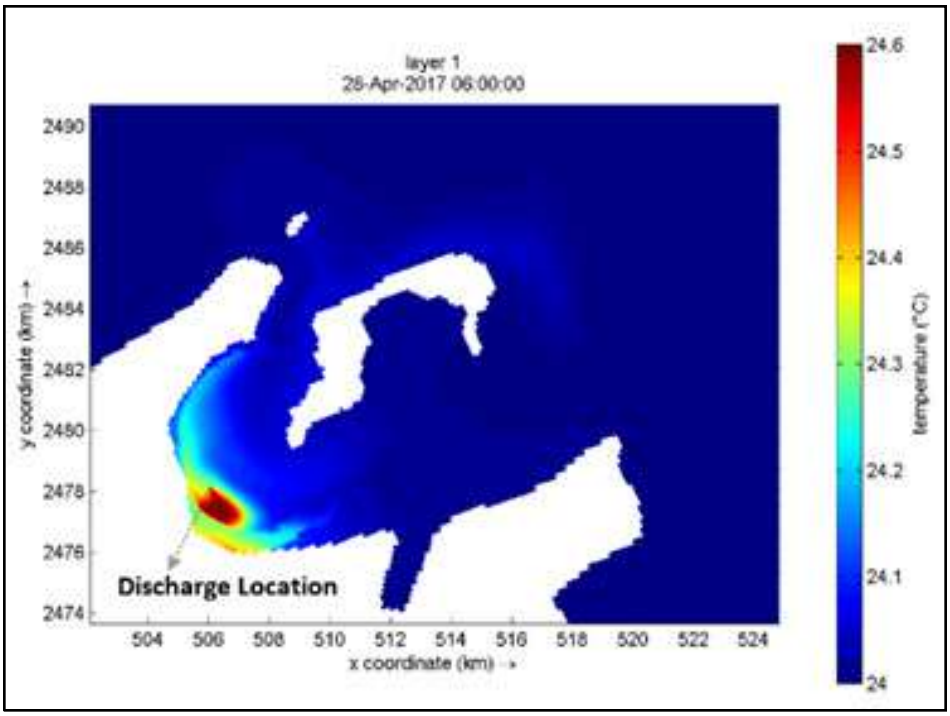


Figure 4-6: Temperature distribution at the end of spring tide cycle

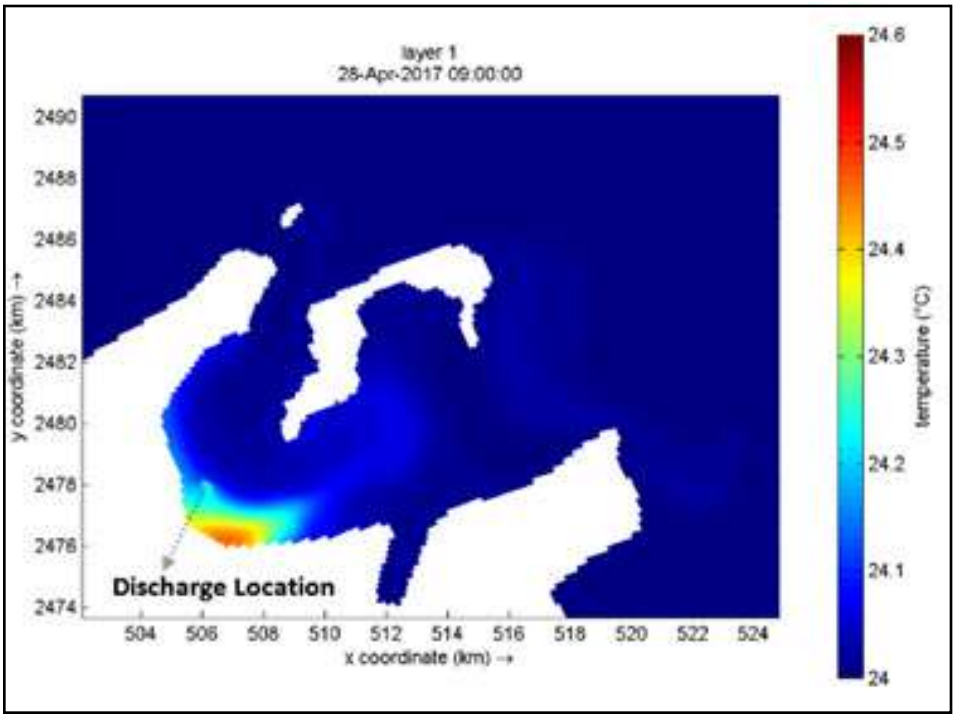


Figure 4-7: Temperature distribution during neap high water

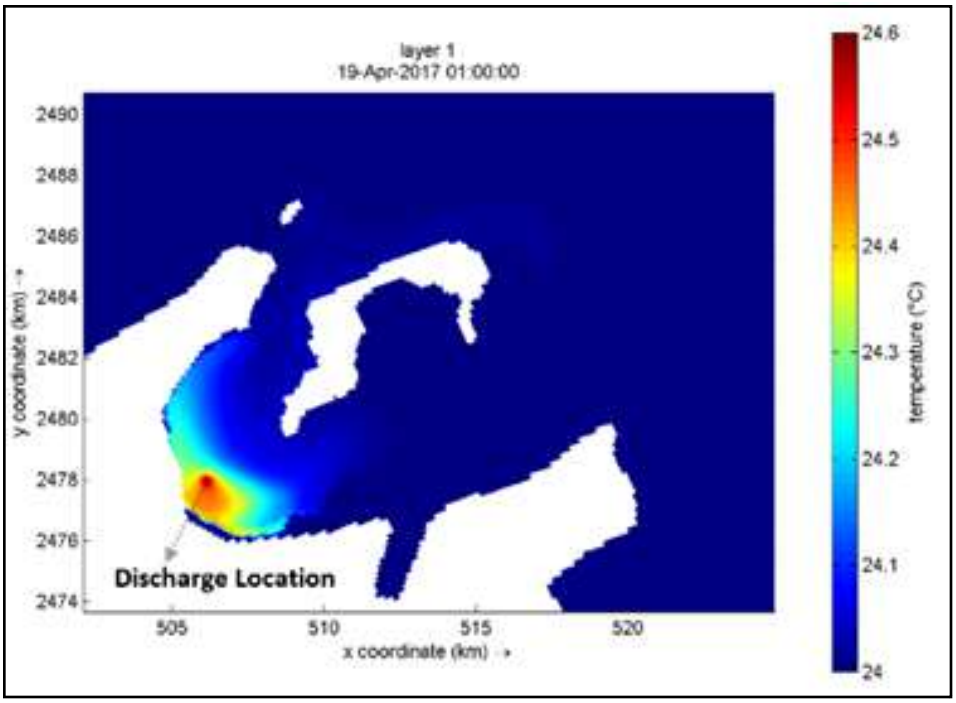


Figure 4-8: Temperature distribution during neap tide peak ebb current

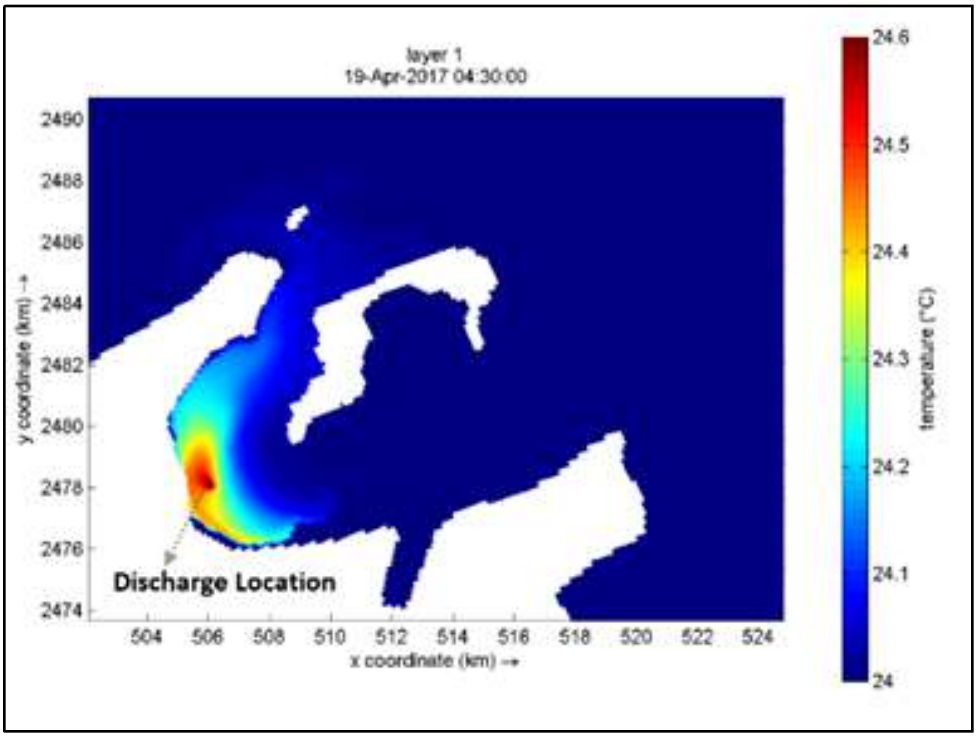


Figure 4-9: Temperature distribution during neap low tide

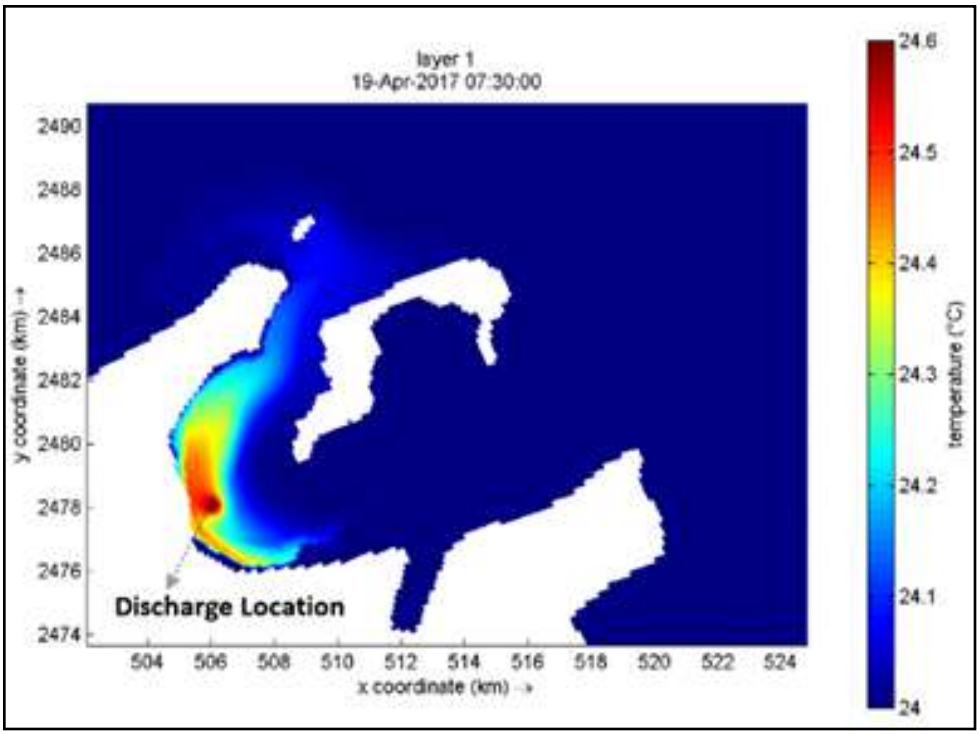


Figure 4-10: Temperature distribution during neap tide peak flood current

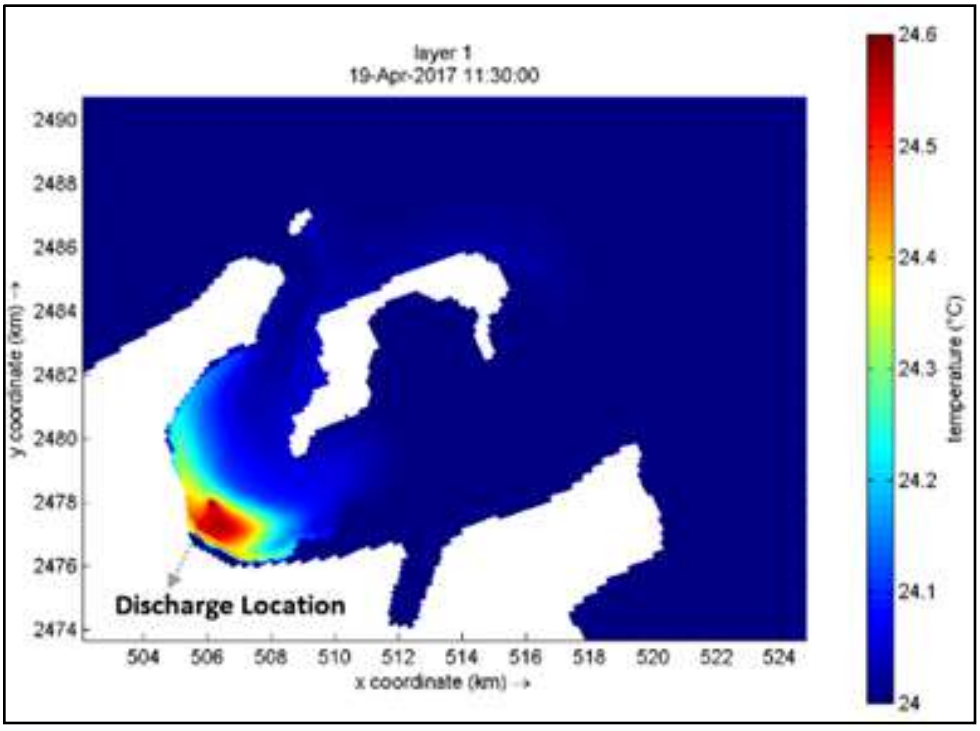


Figure 4-11: Temperature distribution at the end of the neap tide cycle

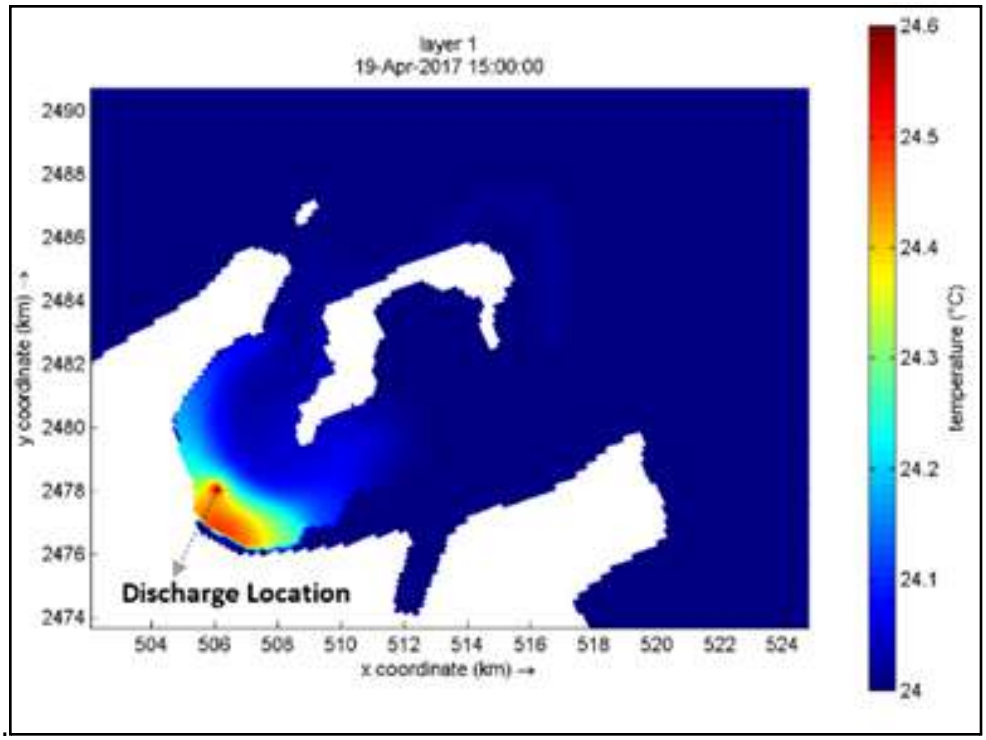


Figure 4-12: Points for data Extraction

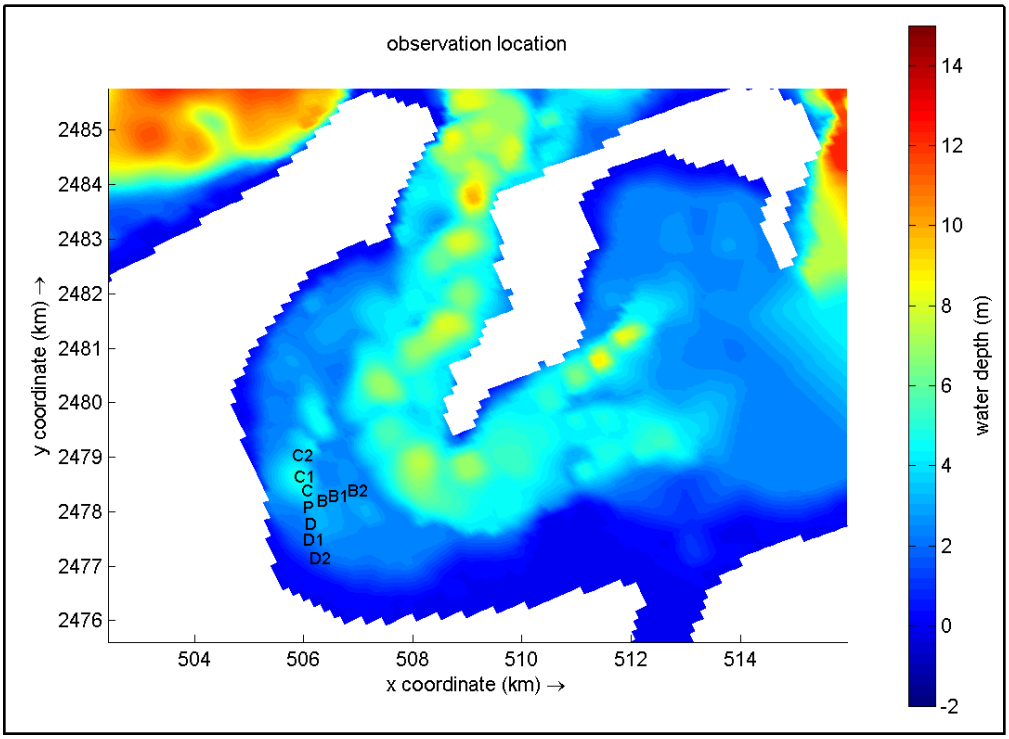


Figure 4-13 Variation of temperature at 300 m from the outfall for prescribed characteristics of the treated wastewater

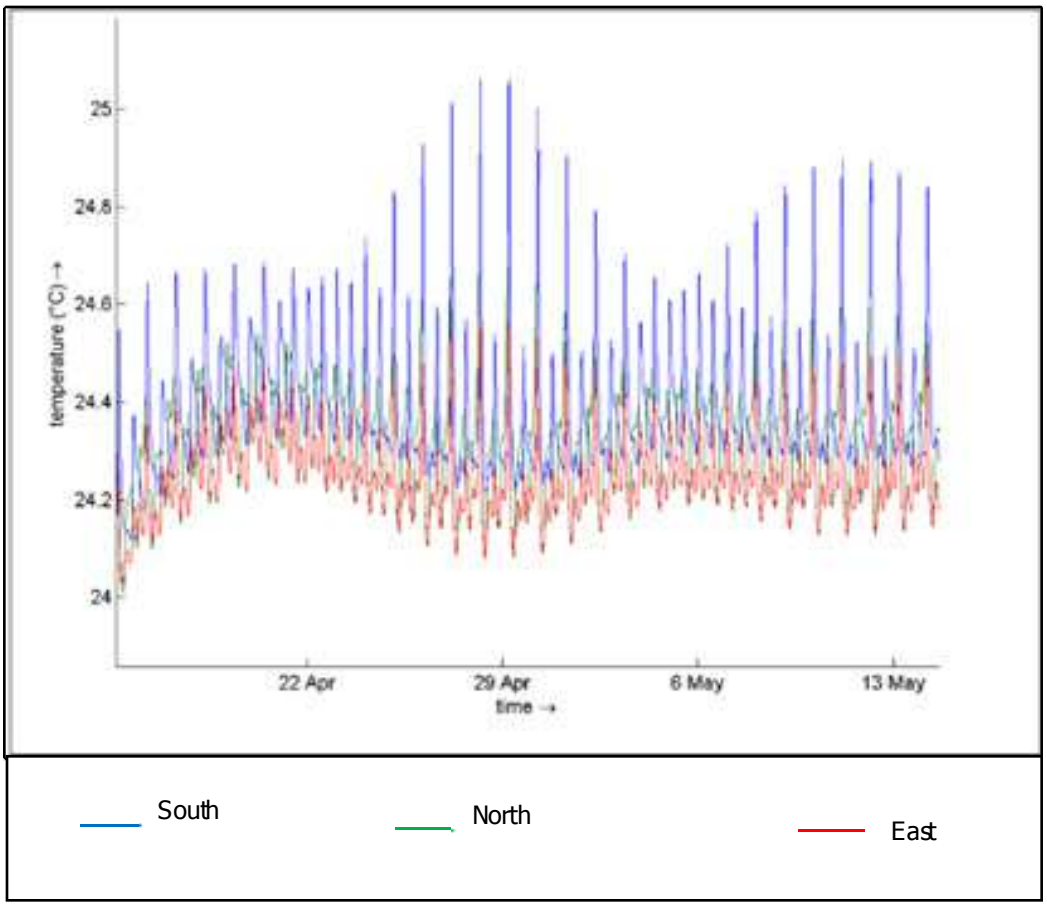


Figure 4-14: Variation of temperature at 600 m from the outfall for prescribed characteristics of the treated waste water

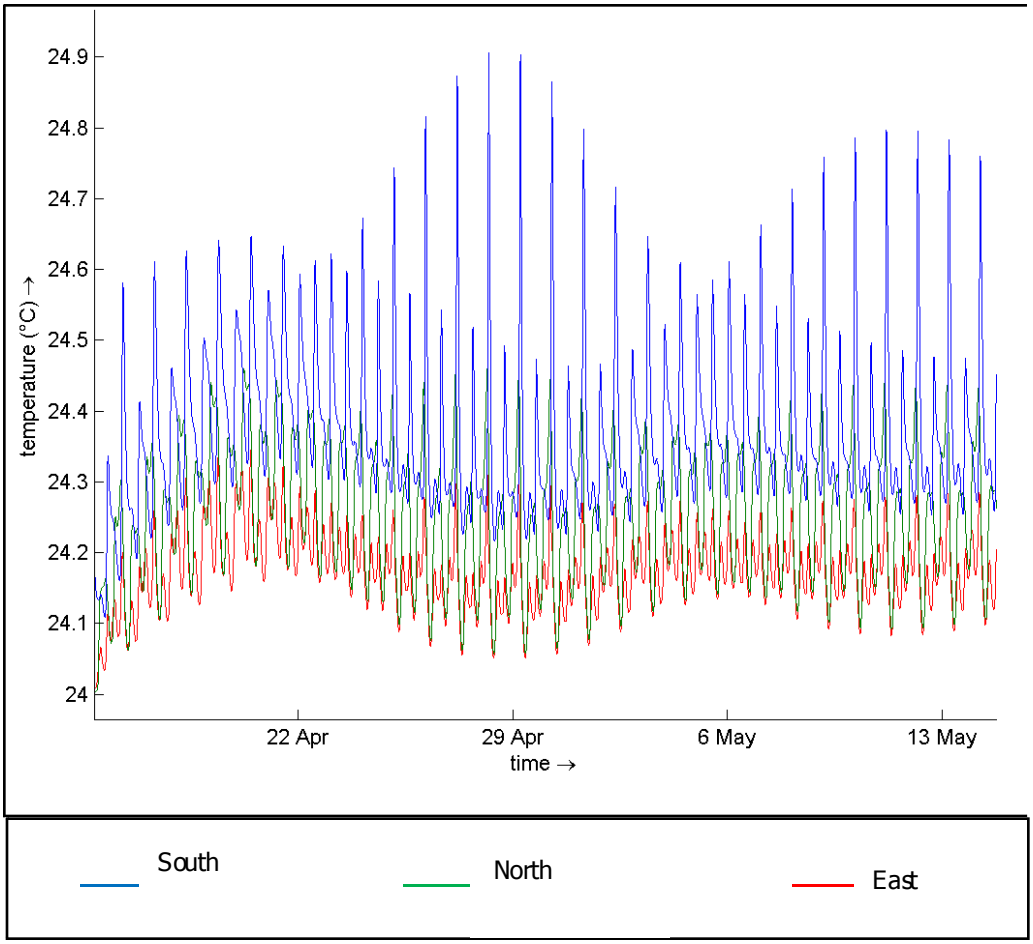


Figure 4-15: Variation of temperature at 1000 m from the outfall for prescribed characteristics of the treated waste water

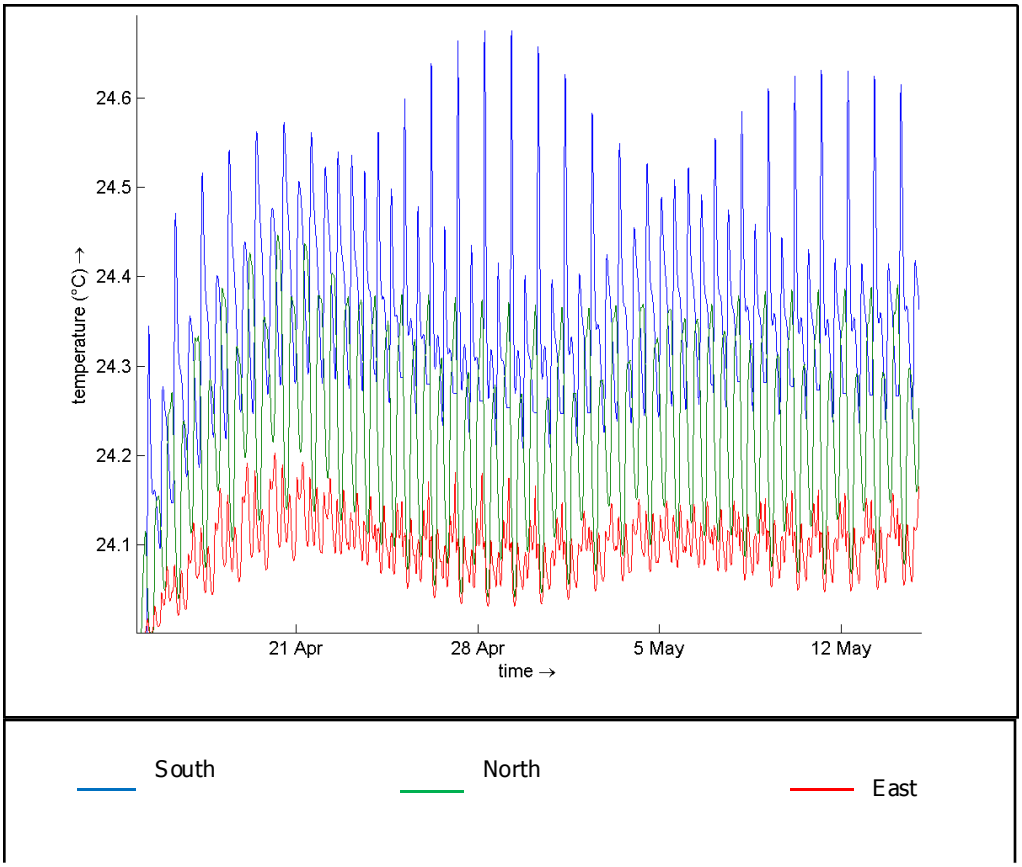


Figure 4-16: Variation of temperature at 300 m from the outfall for observed characteristics of the treated waste water

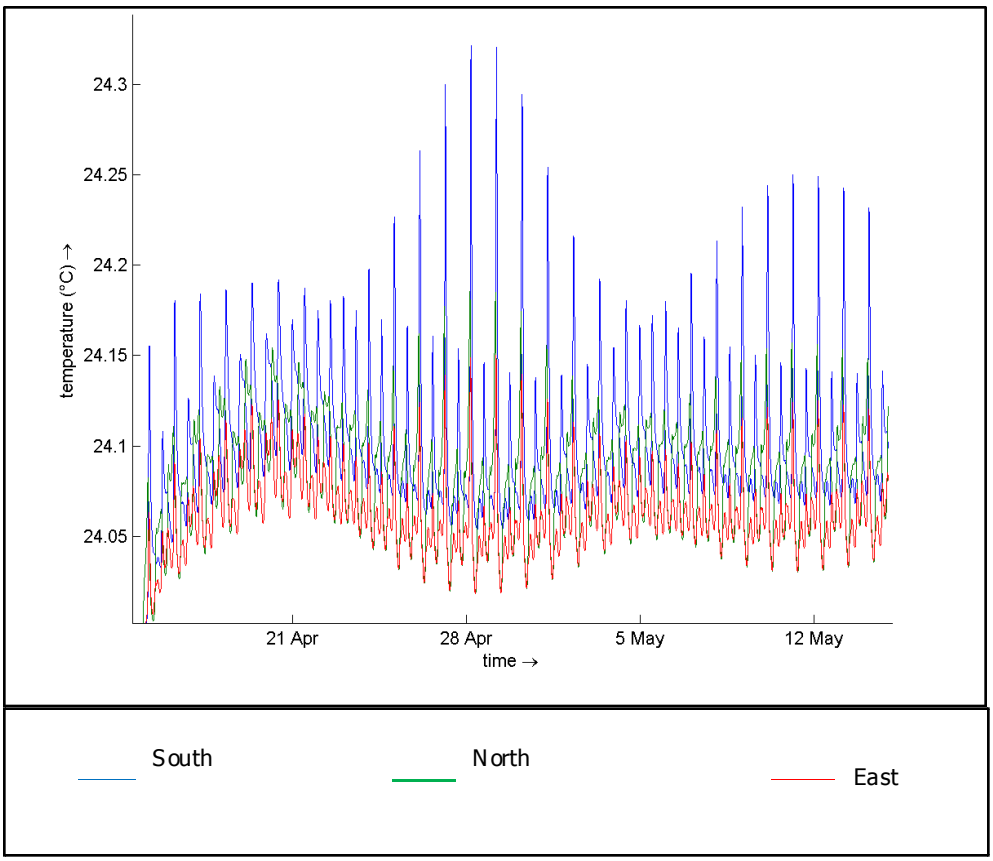


Figure 4-17: Variation of temperature at 600 m from the outfall for observed characteristics of the treated waste water

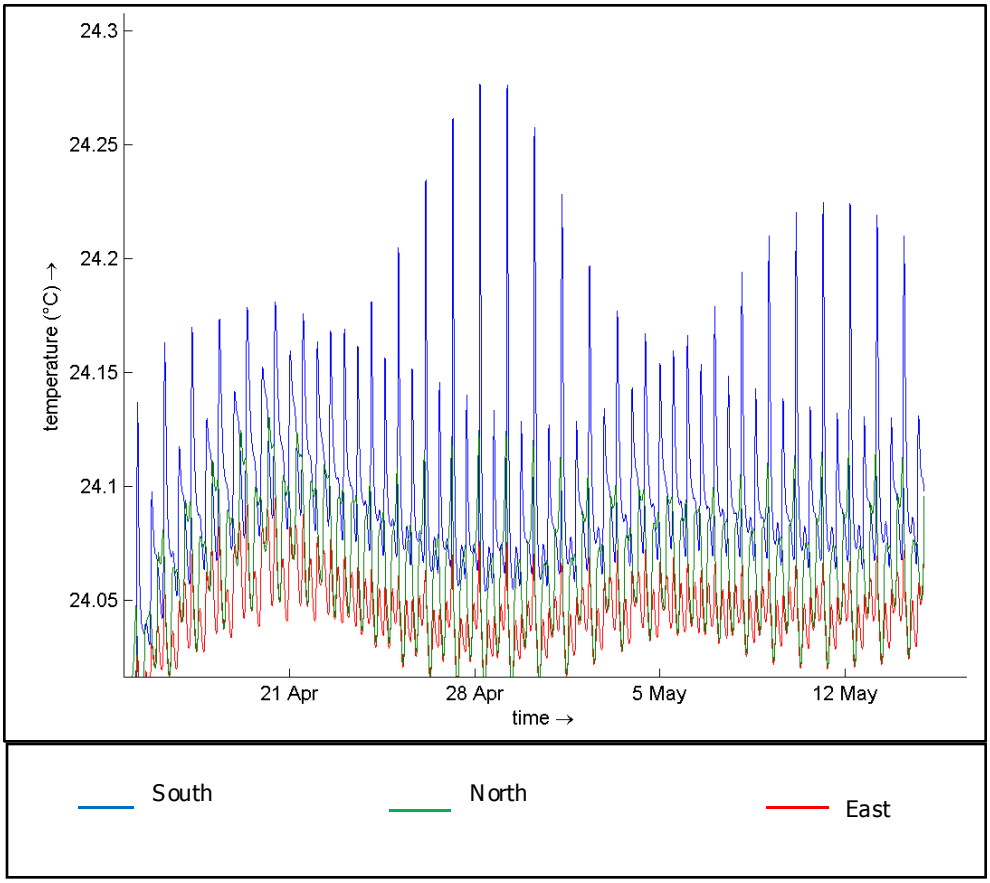
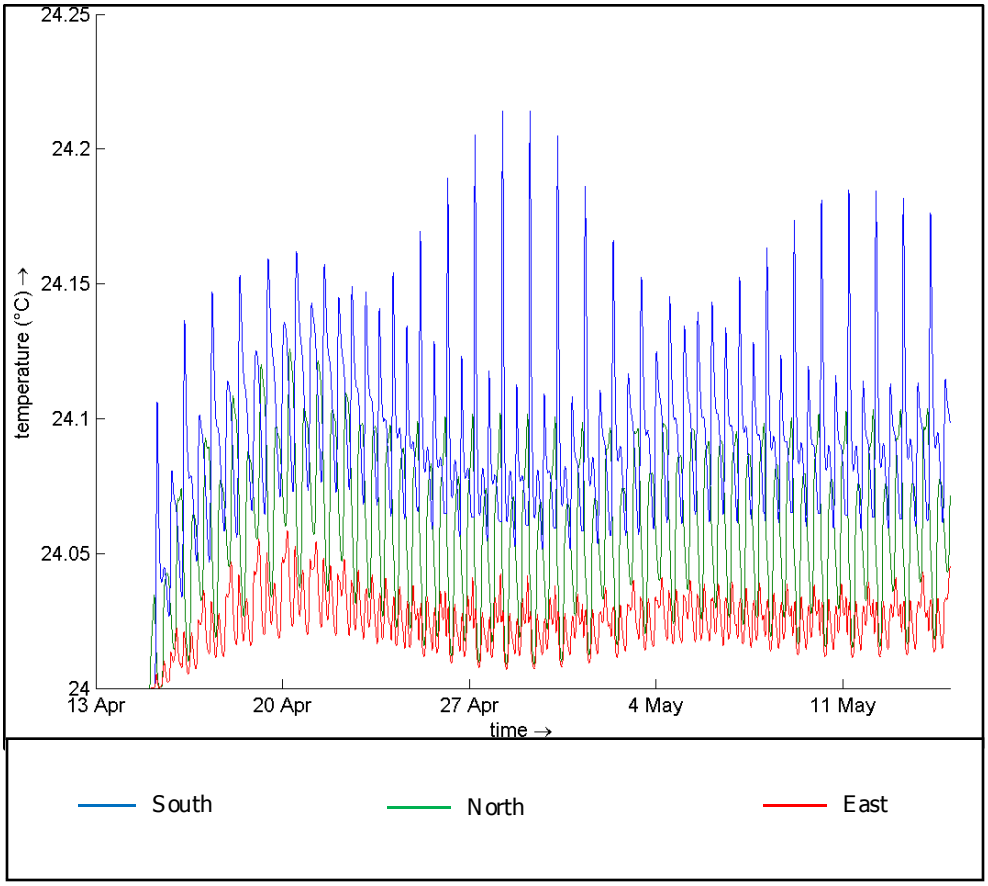


Figure 4-18: Variation of temperature at 1000 m from the outfall for observed characteristics of the treated waste water



4.3 Study on variation of Suspended Solids due to Discharge of Treated Waste Water

The dispersion and dilution of suspended sediment from the discharge is modelled using the Water Quality module (WEQ module) of Delft3d software. The suspended sediment was modelled as particulate inorganic matter and the processes sedimentation and re-suspension were included in the material properties.

Results from simulations were plotted for various stages of each tide cycle. Plots showing variation of concentration of suspended sediments due to GPCB prescribed characteristics of the treated waste water were given for the high tide, peak ebb current, low water, peak flood current and high tide of the next tidal cycle. The results showing suspended sediment concentration variation due to the discharge of treated waste water over a spring tidal cycle and neap tidal cycle are given in ***Figure 4-19*** to ***Figure 4-23*** and ***Figure 4-24*** to ***Figure 4-28*** respectively. In addition, the plots showing variation in the concentration of suspended solids at locations (points of data extractions, ***Figure 4-12***) are given in ***Figure 4-29*** to ***Figure 4-31*** and ***Figure 4-32*** to ***Figure 4-34***.

- The period of high tide is shown in ***Figure 4-19*** and ***Figure 4-24*** for the spring and neap periods respectively. During spring tide, it can be seen that the rise in concentration due to the treated waste water is limited to 20 mg/l and is observed near the shore at a distance of 1800 m-2000 m in the south and south-east direction. During the neap tide, the higher concentrations of around 30 mg/l are observed in the immediate vicinity of the discharge location and the sediment plume with concentrations around 20 mg/l extends to a length of 1800 m in the south and south east directions near the shore.
- The period of peak ebb current is shown in ***Figure 4-20*** and ***Figure 4-25*** for the spring and neap periods respectively. During the spring tide, maximum concentrations of around 20 mg/l extending over a distance of 1200 m from the discharge location are observed in the direction between north and north-west. During the neap tide, maximum concentrations of around 35 mg/l extending over a distance of 1200 m from the discharge location are observed in the direction between north and north-west.
- The period of low tide level is shown in ***Figure 4-21*** and ***Figure 4-26*** for the spring and neap periods respectively. During spring tide, it can be seen that a thin stretch of sediment concentration of around 40 mg/l due to the discharge of treated waste water is seen in the direction between north and north-west up to a distance of 500 m. During the neap tide, a wider sediment plume when compared with that observed during spring tide with concentrations around 40 mg/l is seen extending to a distance of 800 m in the direction between north and north-west. The period of peak flood current is shown in ***Figure 4-22*** and ***Figure 4-27*** for the spring and neap periods respectively. During spring tide, a thin plume with maximum concentration of around 40 mg/l occur in the direction between south and south east up to a distance of 1000 m. During neap tide, a wider plume when to compare to the same during spring tide with maximum concentrations of 30 mg/l occur along the direction between south and south east up-to a distance of 1200 m.
- At the end of the tidal cycle i.e. at high water as shown in ***Figure 4-23*** and ***Figure 4-28***, it can be seen that the patterns are nearly similar to the same as given in ***Figure 4-19*** and ***Figure 4-28*** the suspended solids increase values are nearly same. This means that the treated waste water caused changes in the surrounding areas are not accruing in time but are transient in nature.

- It can also be seen that during the entire tide cycles for both the spring and neap tides, the maximum increase near the Beyt Dwarka Island and the Okha harbour are less than 1 mg/l which can be considered negligible.

4.3.1 Temporal variation of SS concentrations at different distances from the outfall location for GPCB prescribed characteristics and observed characteristics

Prescribed characteristics

Variation of suspended solids concentrations due to prescribed characteristics of the outfall over the entire simulation period at locations along the South, North and East directions at distances 300 m, 600 m and 1000 m from the discharge location are given in ***Figure 4-29*** to ***Figure 4-31***. It was observed that the sediment concentration increase is dissipated in the eastern direction very rapidly, i.e. towards the Beyt Dwarka Island the peak change in suspended solids is 15 mg/l, 10mg/l and 5 mg/l at 300 meters, 600 meters and 1000 meters respectively. In the North direction the peak change in suspended solids concentration is 40 mg/l, 35 mg/l and 27 mg/l at 300 meters, 600 meters and 1000 meters respectively. In the south direction the peak change in suspended solids concentration is 70 mg/l, 50 mg/l and 40 mg/l at 300 meters, 600 meters and 1000 meters respectively. From the plots, it can also be seen that there is no cumulative increase in suspended solids concentration over period of one month which implies that the area in the vicinity of the discharge of treated waste water is marked by good flushing characteristics.

Observed characteristics

The variation of the suspended sediment concentration for the observed characteristics of the treated waste water are given in ***Figure 4-32*** to ***Figure 4-34*** over the entire simulation period at locations along the South, North and East directions at distances 300 m, 600 m, 1000 m from the discharge location. Results show that for the treated waste water released with observed characteristics, the increase in suspended sediment concentration at a distance of 300 m from the treated waste water discharge location is around 17.0 mg/l in the south direction, 8.0 mg/l in the north direction and 5.0 mg/l in the east direction. At a distance of 600m from the treated waste water discharge location, the increase in suspended sediment concentration is around 15.0 mg/l in the south direction, 7.0 mg/l in the north direction and 3.0 mg/l in the east direction. At a distance of 1000 m from the treated waste water discharge location, the increase in suspended sediment concentration is around 11.0 mg/l in the south direction, 6.0 mg/l in the north direction and 1.0 mg/l in the east direction.

Figure 4-19: Concentration of the suspended solids in g/m³ during spring tide High Water

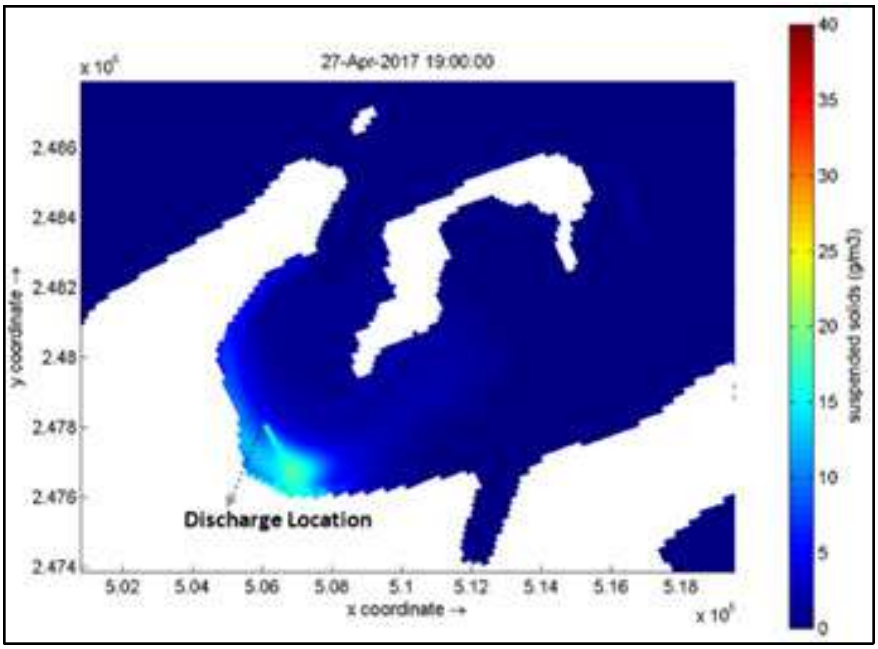


Figure 4-20: Concentration of the suspended solids in g/m³ during spring tide peak ebb current

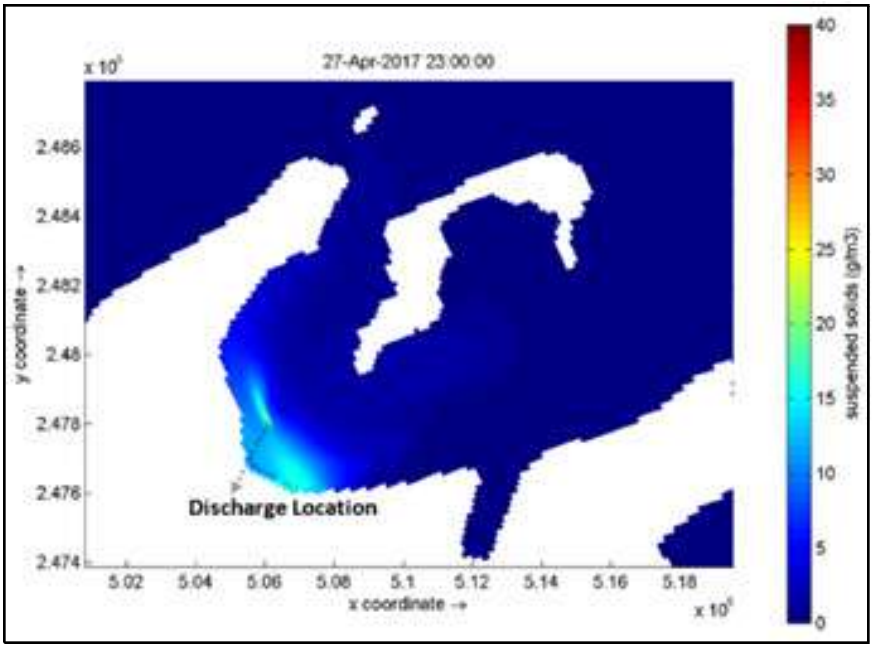


Figure 4-21: Concentration of the suspended solids in g/m³ during spring tide low water

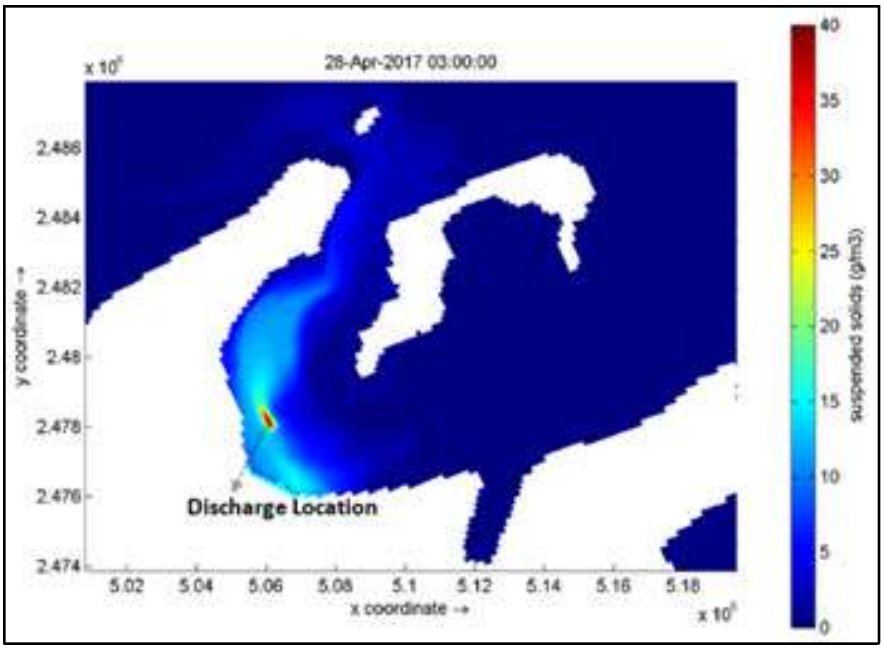


Figure 4-22: Concentration of the suspended solids in g/m³ during spring tide peak flood current

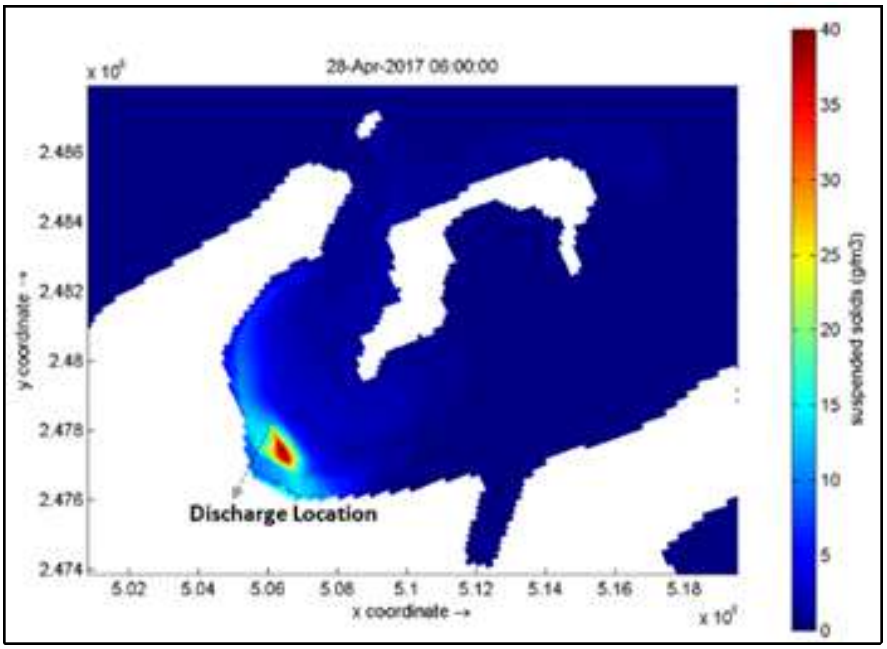


Figure 4-23: Concentration of the suspended solids in g/m³ at the end spring tide cycle

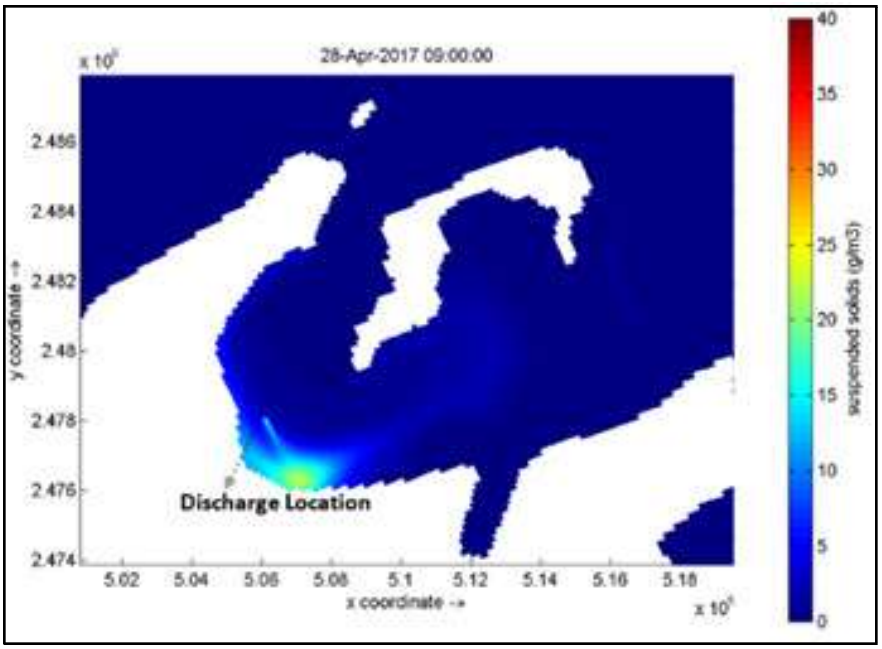


Figure 4-24: Concentration of the suspended solids in g/m³ during neap tide High Water

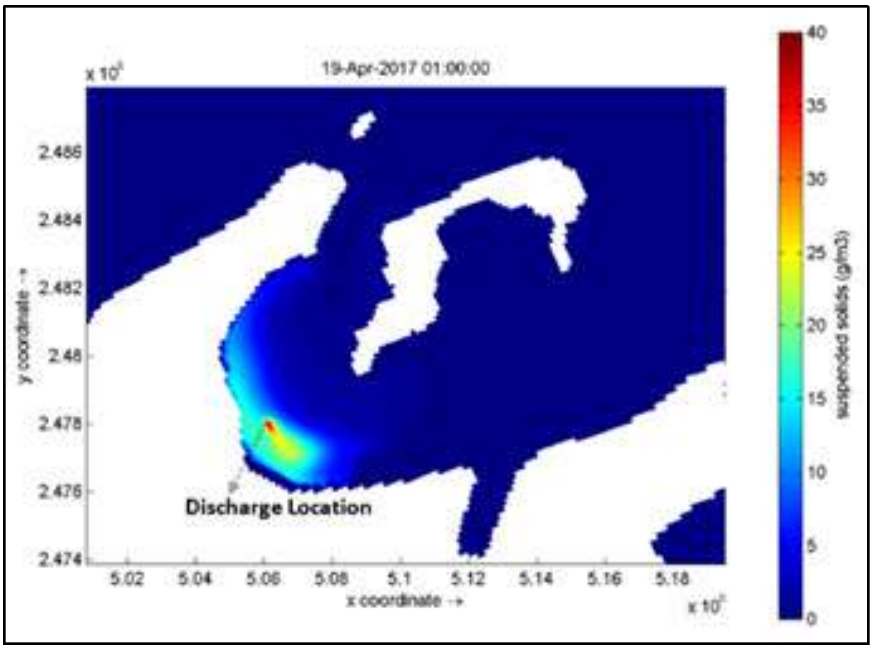


Figure 4-25: Concentration of the suspended solids in g/m³ during neap tide peak ebb current

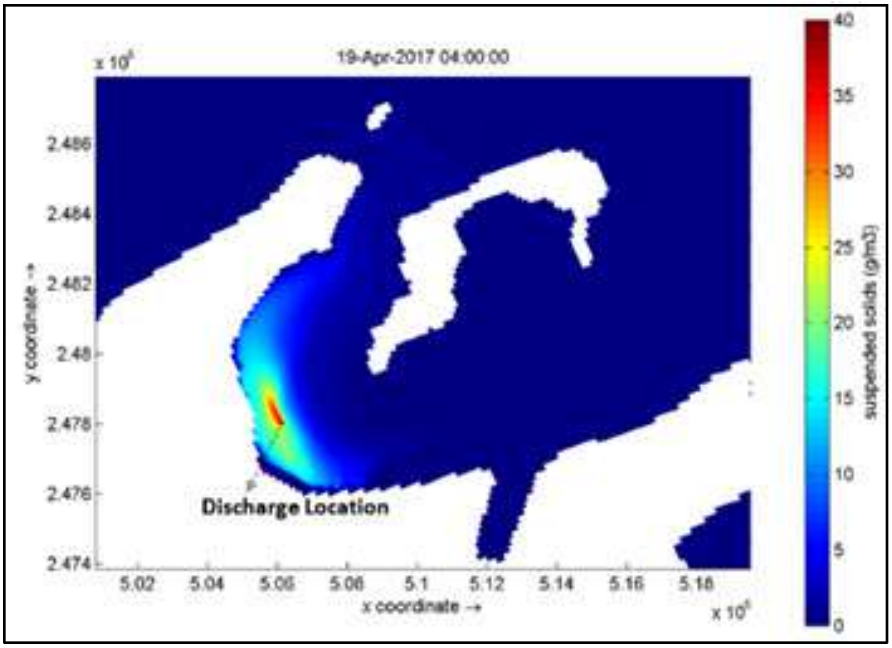


Figure 4-26: Concentration of the suspended solids in g/m³ during neap tide low water

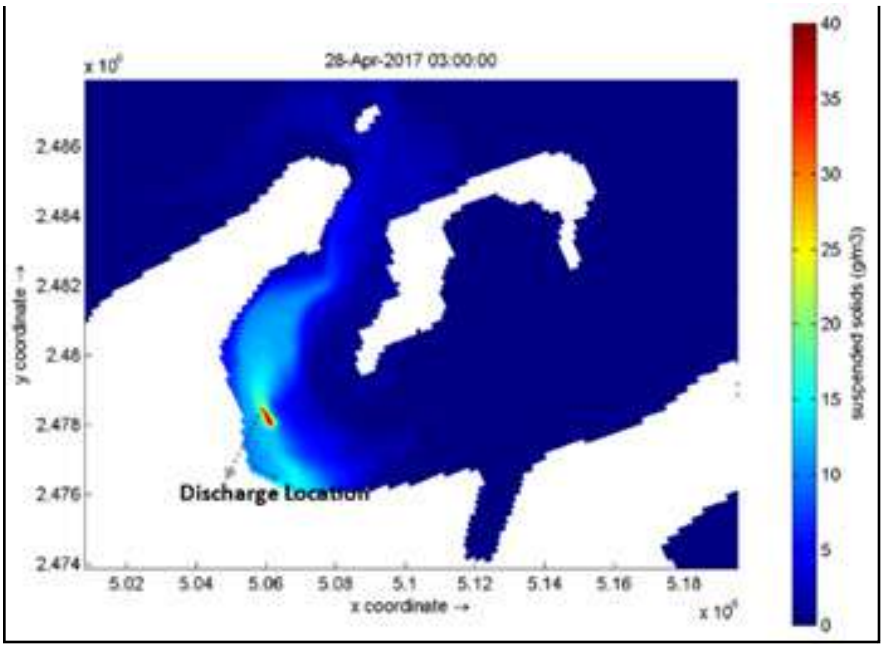


Figure 4-27: Concentration of the suspended solids in g/m³ during neap tide peak flood tide

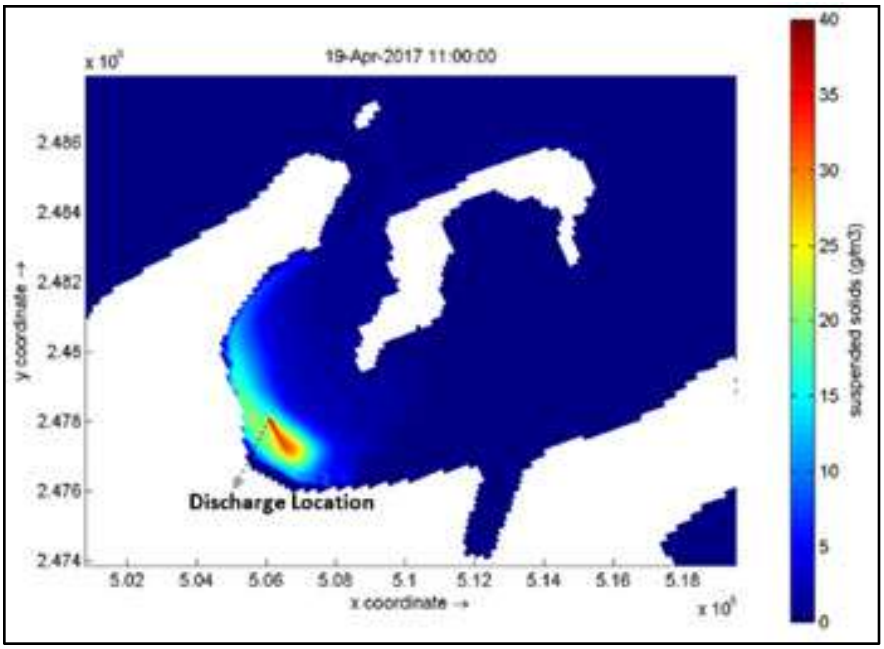


Figure 4-28: Concentration of the suspended solids in g/m³ at the end of neap tide cycle

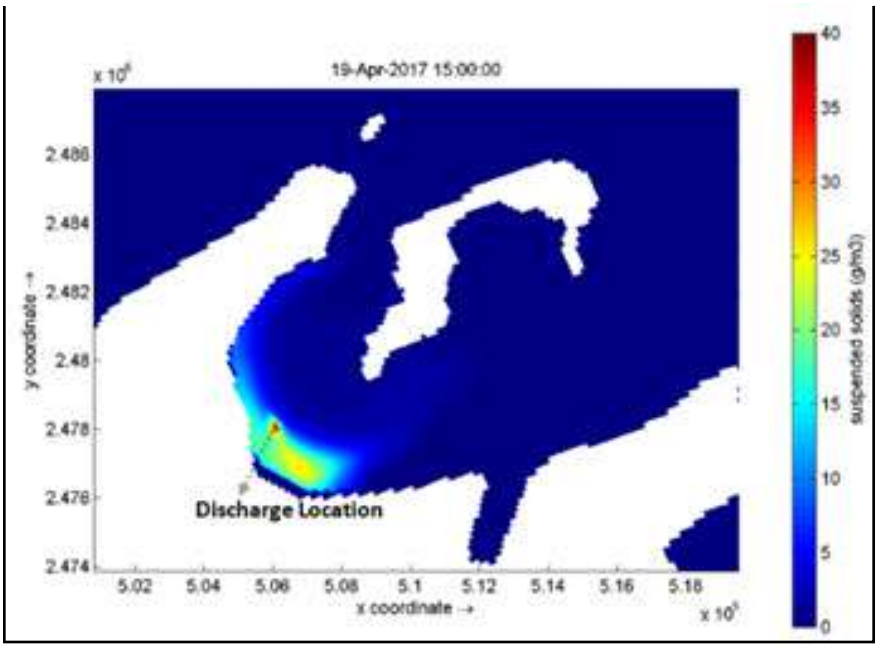


Figure 4-29: Variation of suspended solids at 300 m from the Outfall Point for prescribed characteristics of the treated waste water

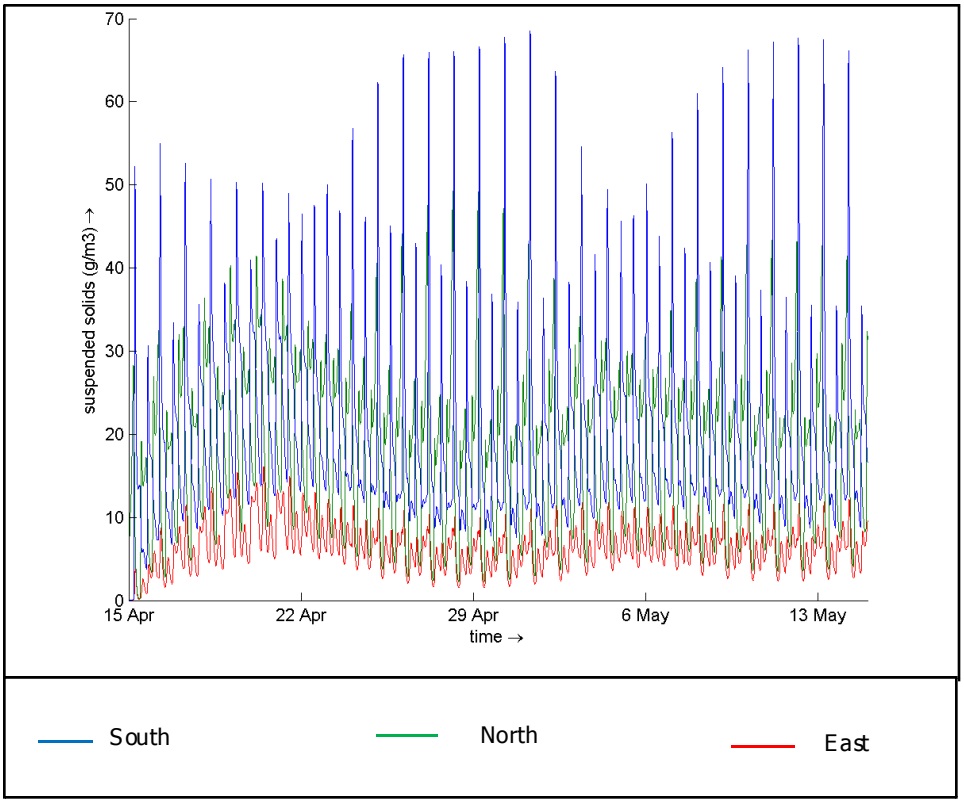


Figure 4-30: Variation of suspended solids at 600 m from the Outfall Point for prescribed characteristics of the treated waste water

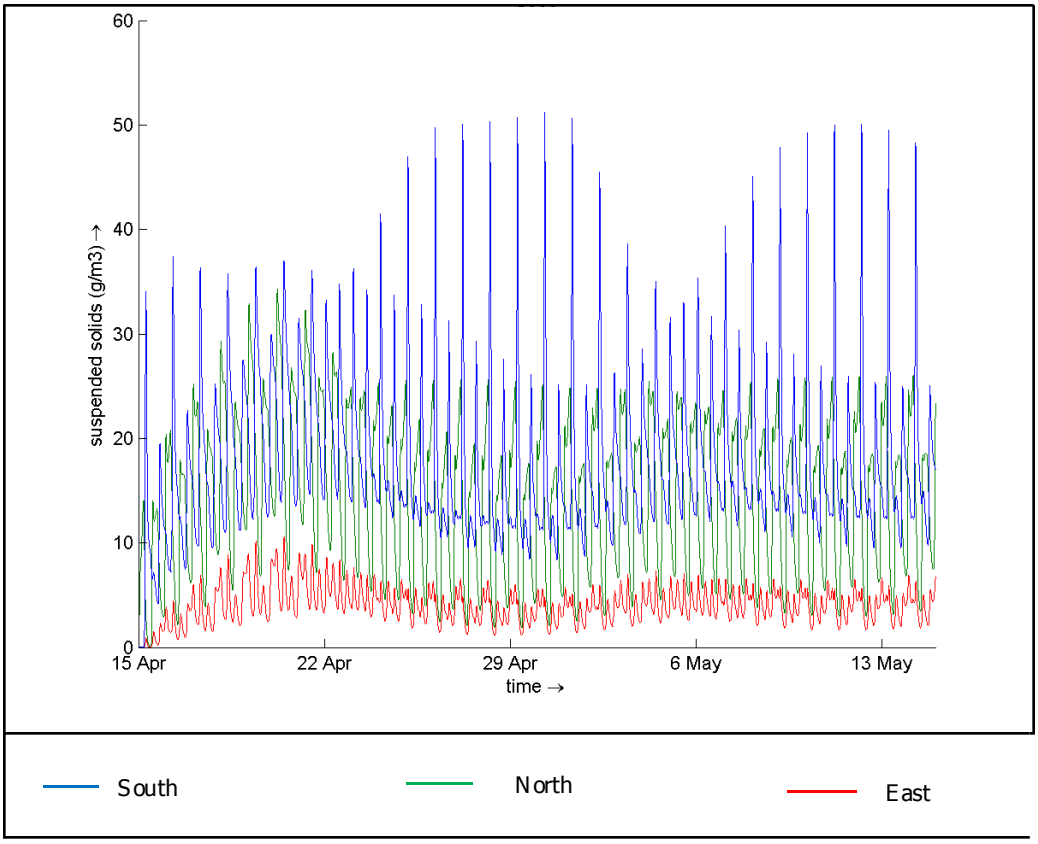


Figure 4-31: Variation of suspended solids at 1000 m from the Outfall Point for prescribed characteristics of the treated waste water

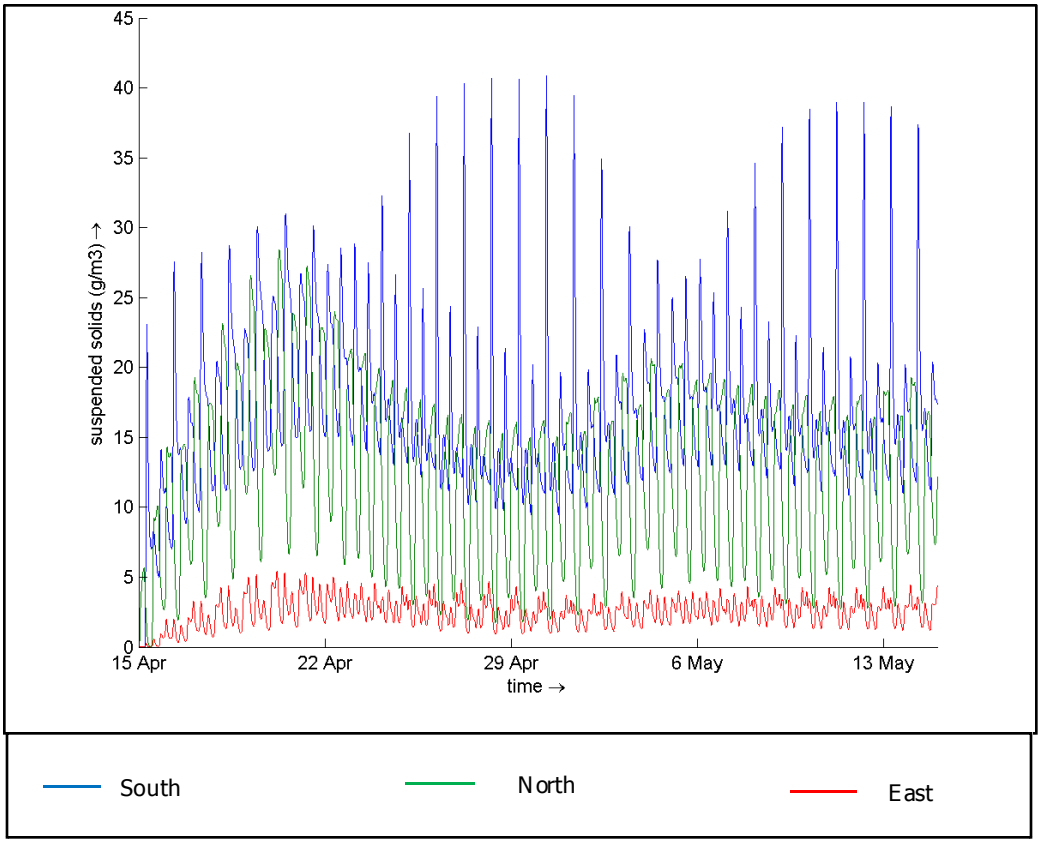


Figure 4-32: Variation of SS concentration at 300 m from the outfall for observed characteristics of the treated waste water

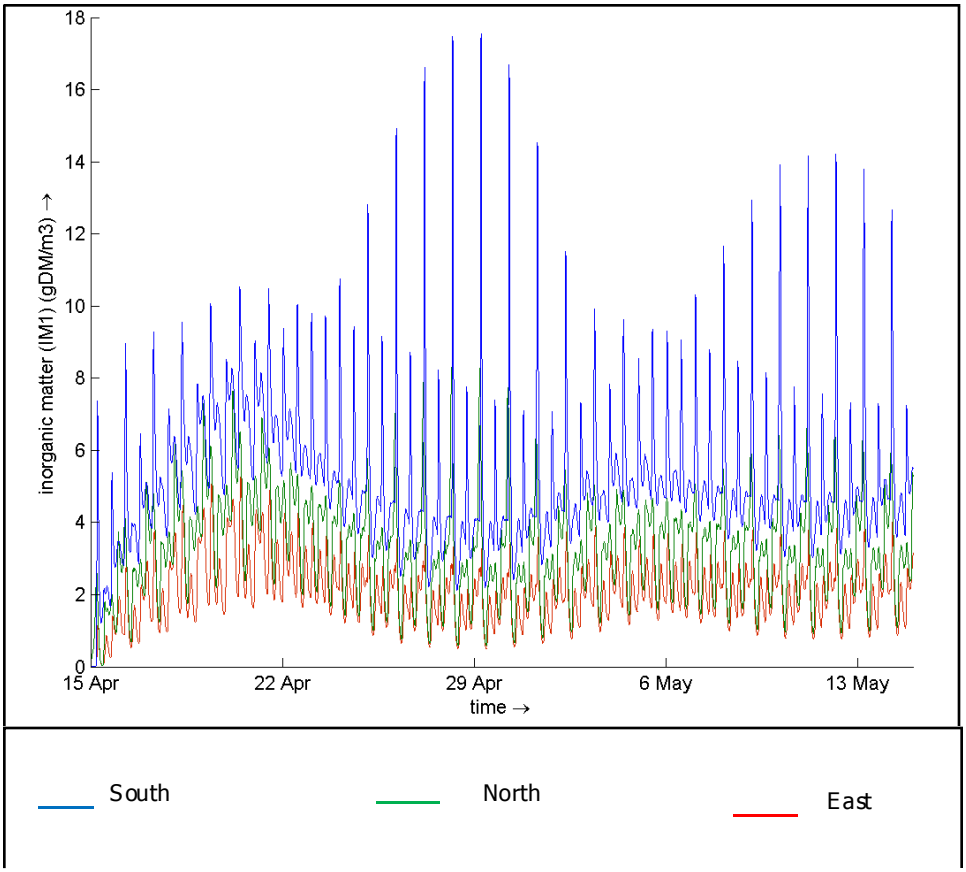


Figure 4-33: Variation of SS concentration at 600 m from the outfall for observed characteristics of the treated waste water

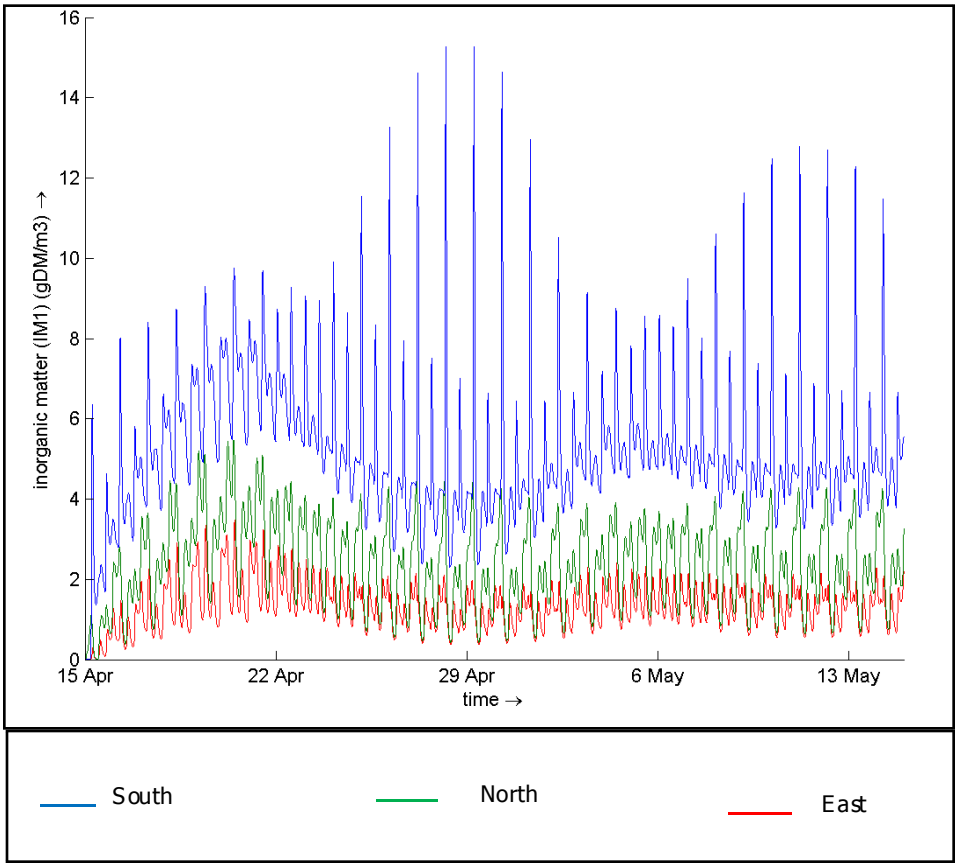
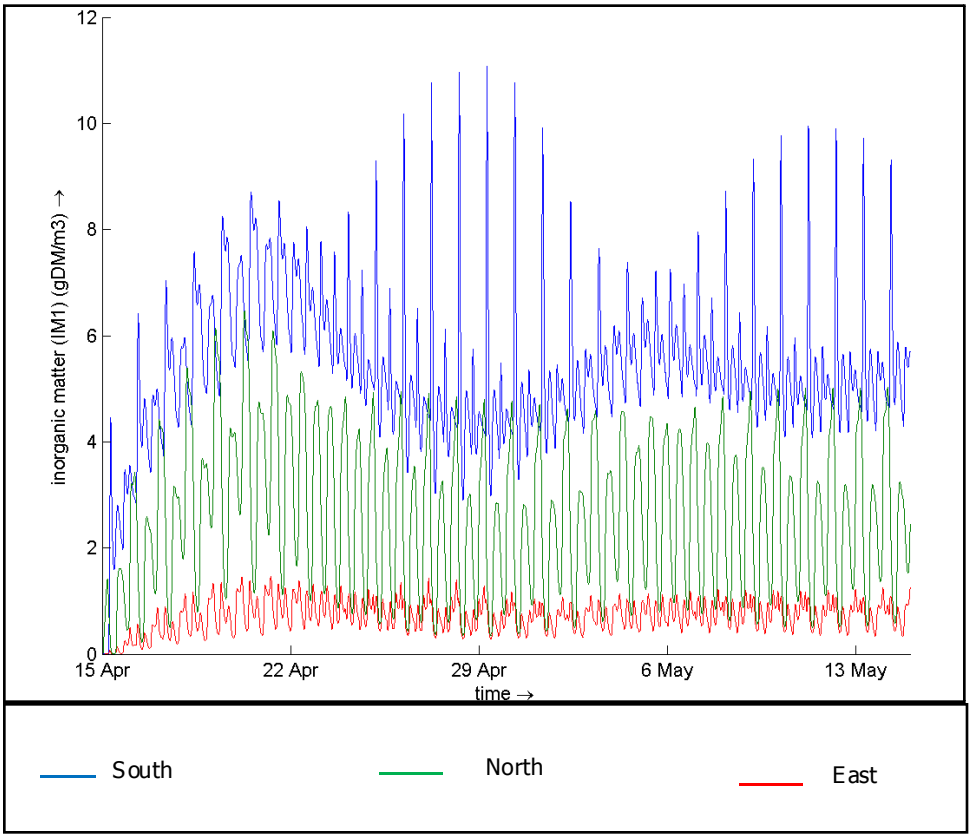


Figure 4-34: Variation of SS concentration at 1000 m from the outfall for observed characteristics of the treated waste water



4.4 Study on variation of Ammonia due to Discharge of Treated Waste Water

The dispersion and dilution of Ammonical Nitrogen from the discharge of treated waste water is modelled using the Water Quality module (WEQ module) of Delft3d software. Ammonia was modelled as dissolved inorganic matter. Results from simulations were plotted for various stages of each tide cycle. Plots showing variation of concentration of Ammonia were given for the high tide, peak ebb current, low water, peak flood current and high tide of the next tidal cycle. The results showing Ammonia concentration variation due to the treated waste water discharge for the GPCB prescribed characteristics of the treated waste water over a spring tidal cyde and neap tidal cycle are given in ***Figure 4-35*** to ***Figure 4-39*** and ***Figure 4-40*** to ***Figure 4-44*** respectively. In addition, the plots showing variation in the concentration of Ammonia at locations (points of data extraction, ***Figure 4-12***) are given in ***Figure 4-45*** to ***Figure 4-47***.

- The period of high tide is shown in ***Figure 4-35*** and ***Figure 4-40*** for the spring and neap periods respectively. During spring tide, it can be seen that the maximum increase in ammonia concentration due to discharge of treated waste water is limited to 0.2 mg/l and is observed near the shore at a distance of 1800 m – 2000 m in the south and south-east direction. During the neap tide, the higher concentrations of around 0.3 mg/l are observed in the immediate vicinity of

the discharge location and the plume with ammonia concentrations around 0.25 mg/l extends to a length of 1800 in the south and south-east directions near the shore.

- The period of peak ebb current is shown in ***Figure 4-36*** and ***Figure 4-41*** for the spring and neap periods respectively. During the spring tide, a thin plume of maximum ammonia concentrations of around 0.2 mg/l extending over a distance of 800 m from the discharge location are observed in the direction between north and north west. During the neap tide, maximum ammonia concentrations of around 0.3 mg/l extending over a distance of 1200 m from the discharge location are observed in the direction between north and north-west.
- The period of low tide level is shown in ***Figure 4-37*** and ***Figure 4-42*** for the spring and neap periods respectively. During spring tide, it can be seen that a thin stretch of sediment concentration of around 0.3 mg/l due to the treated waste water is seen in the direction between north and north-west up to a distance of 500 m. During the neap tide, a wider plume when compared with that observed during spring tide with concentrations around 0.3 mg/l is seen extending to a distance of 800 m in the direction between north and north-west.
- The period of peak flood current is shown in ***Figure 4-38*** and ***Figure 4-43*** for the spring and neap periods respectively. During spring tide, a plume with maximum concentration of around 0.3 mg/l occurs in the direction between south and south east at a distance of 1000 m. During neap tide, a wider plume when to compare to the same during spring tide with maximum concentrations of 0.3 mg/l occur along the direction between south and south east up-to a distance of 1200 m.
- At the end of the tidal cycle i.e. at high water as shown in ***Figure 4-39*** and ***Figure 4-44***, it can be seen that the patterns are nearly similar to the same as given in ***Figure 4-19*** and ***Figure 4-23*** and the ammonia increase values are nearly same. This means that the treated waste water caused changes in the surrounding areas are not accruing in time but are transient in nature.

4.4.1 Temporal variation of Ammonia concentrations at different distances from the outfall location for GPCB prescribed characteristics and observed characteristics

Prescribed Characteristics

It can also be seen that during the entire tide cycles for both the spring and neap tides, the maximum increase in ammonia concentrations near the Beyt Dwarka Island and the Okha harbour are less than 0.05 mg/l which can be considered negligible. ***Figure 4-45*** to ***Figure 4-47*** give the ammonia concentration variation over the entire simulation period at locations along the South, North and East directions at distances 300 m, 600 m, and 1000 m from the discharge location. It was observed that the ammonia concentration increase is dissipated in the eastern direction very rapidly, i.e. towards the Beyt Dwarka Island and the peak change in concentration is 0.15 mg/l, 0.08 mg/l and 0.03 mg/l at 300 meters, 600 meters and 1000 meters respectively. In the North direction the peak change in ammonia concentration is 0.5 mg/l, 0.35 mg/l and 0.27 mg/l at 300 meters, 600 meters and 1000 meters respectively. In the south direction the peak change in ammonia is 0.7 mg/l, 0.5 mg/l and 0.4 mg/l at 300 meters, 600 meters and 1000 meters respectively. From the plots, it can also be seen that there is no cumulative increase in ammonia concentration over period of one month which implies that the area in the vicinity of the treated waste water discharge is marked by good flushing characteristics.

Observed Characteristics

The variation of the ammonia concentrations due to the observed characteristics of the treated waste water are given in ***Figure 4-48*** to ***Figure 4-50*** over the entire simulation period at locations along the South, North and East directions at distances 300m, 600m, 1000m from the discharge location. Results show that for the treated waste water released with observed characteristics, the increase in ammonia concentration at a distance of 300 m from the treated waste water discharge location is around 0.18 mg/l in the south direction, 0.1 mg/l in the north direction and 0.06 mg/l in the east direction. At a distance of 600m from the treated waste water discharge location, the increase in ammonia concentration is around 0.15 mg/l in the south direction, 0.07 mg/l in the north direction and 0.05 mg/l in the east direction. At a distance of 1000 m from the treated waste water discharge location, the increase in ammonia concentration is around 0.12 mg/l in the south direction, 0.07 mg/l in the north direction and 0.03 mg/l in the east direction.

Figure 4-35: Concentration of the ammonia in g/m³ during spring tide high water

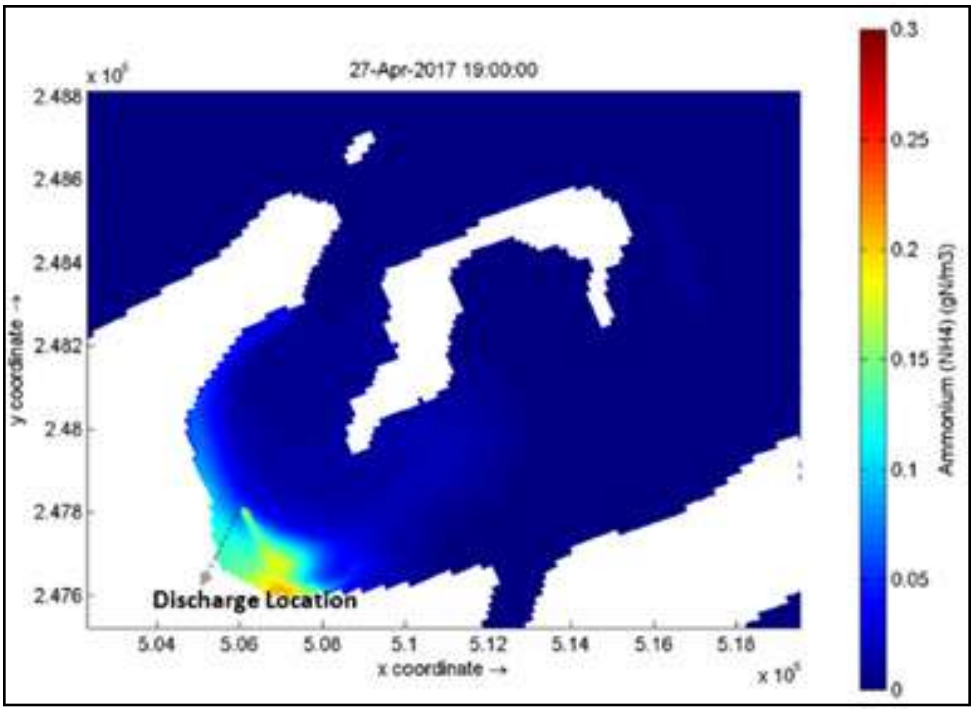


Figure 4-36: Concentration of the ammonia in g/m³ during spring tide peak ebb current

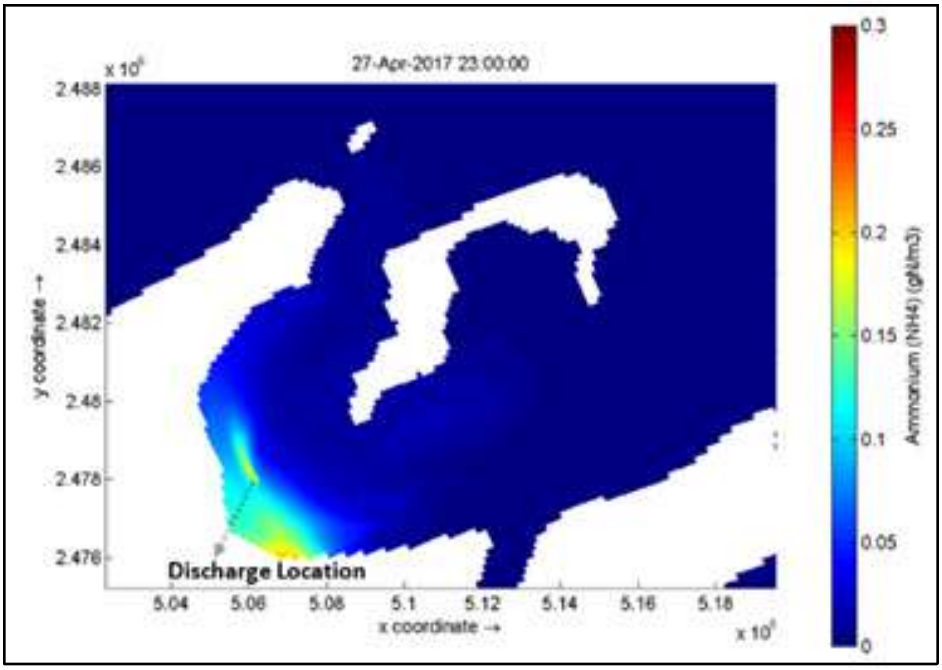


Figure 4-37: Concentration of the ammonia in g/m³ during spring tide low water

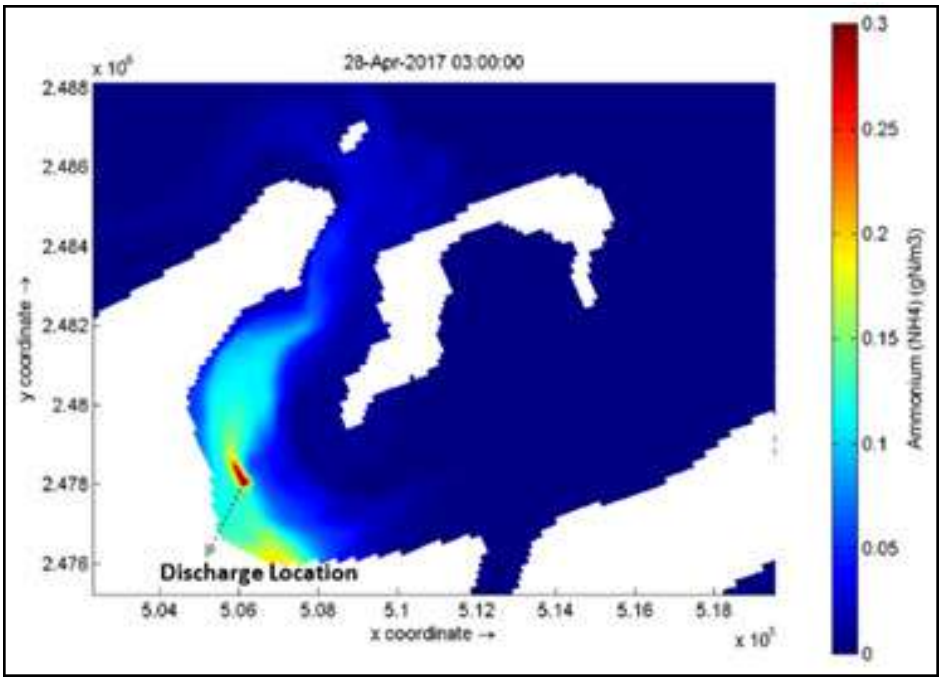


Figure 4-38: Concentration of the ammonia in g/m³ during spring tide peak flood current

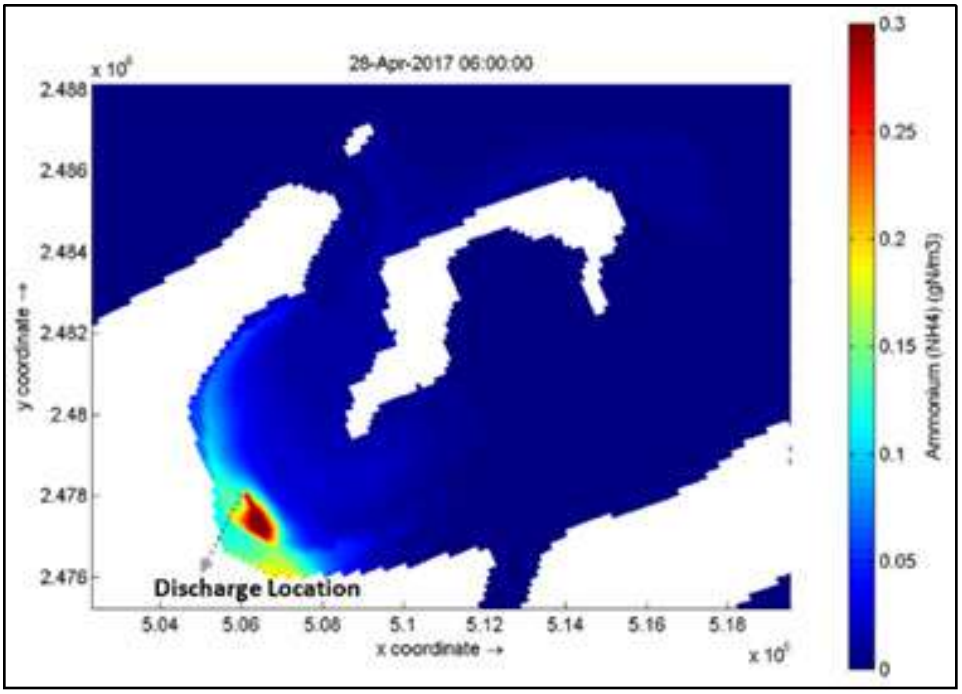


Figure 4-39: Concentration of the ammonia in g/m³ at the end spring tide cycle

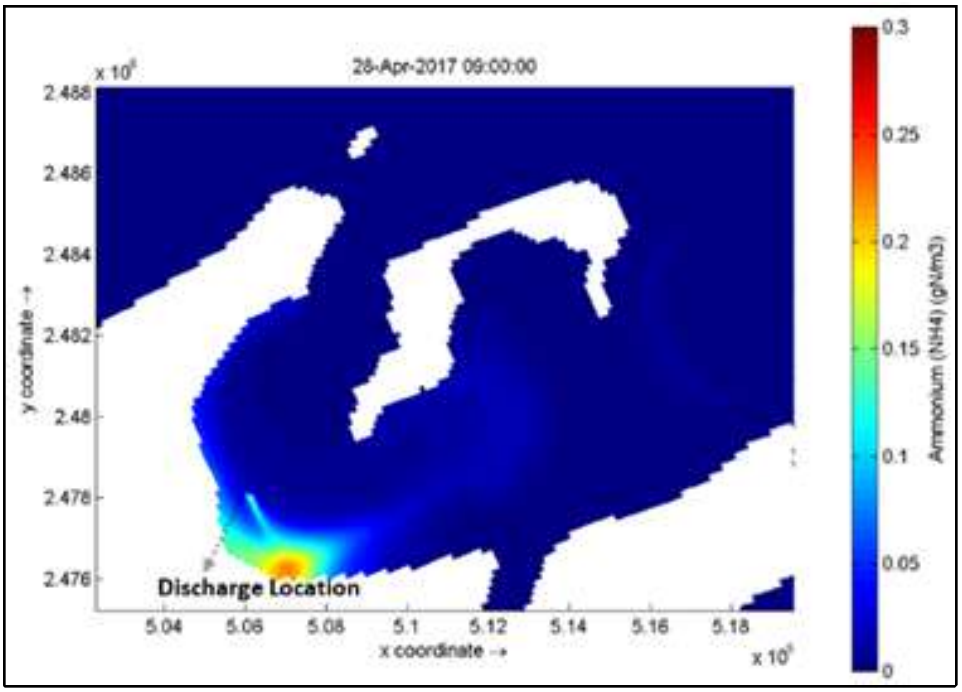


Figure 4-40: Concentration of the ammonia in g/m³ during neap tide high water

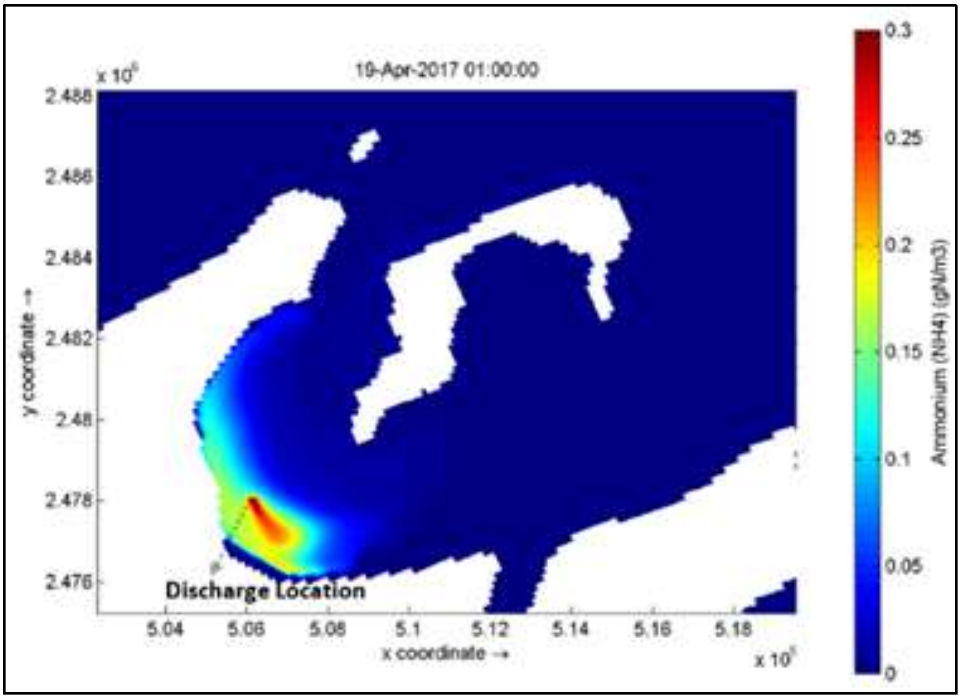


Figure 4-41: Concentration of the ammonia in g/m³ during neap tide peak ebb current

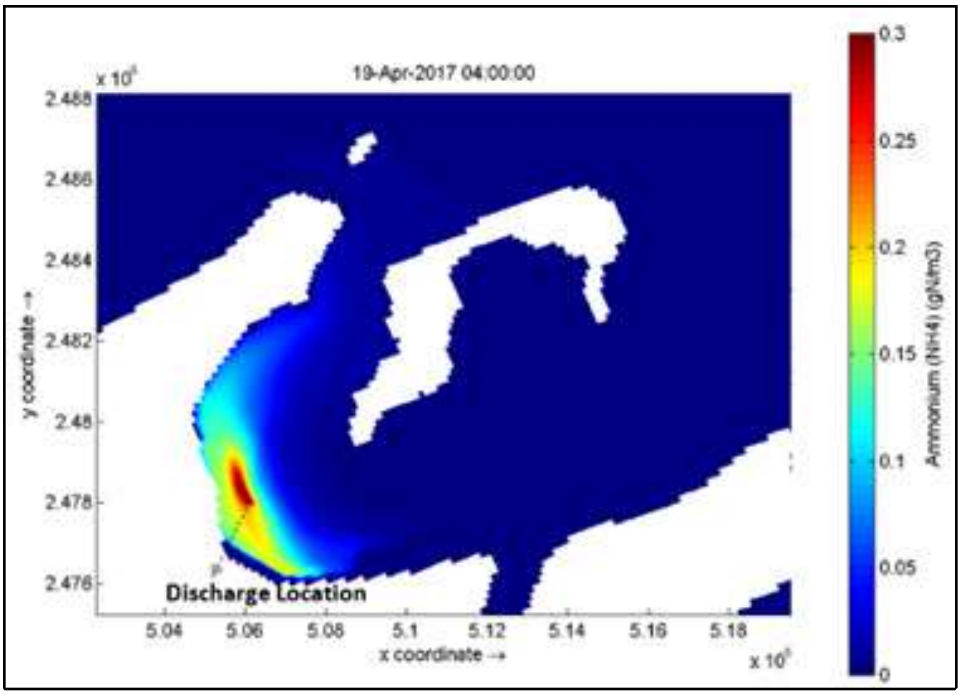


Figure 4-42: Concentration of the ammonia in g/m³ during neap tide low water

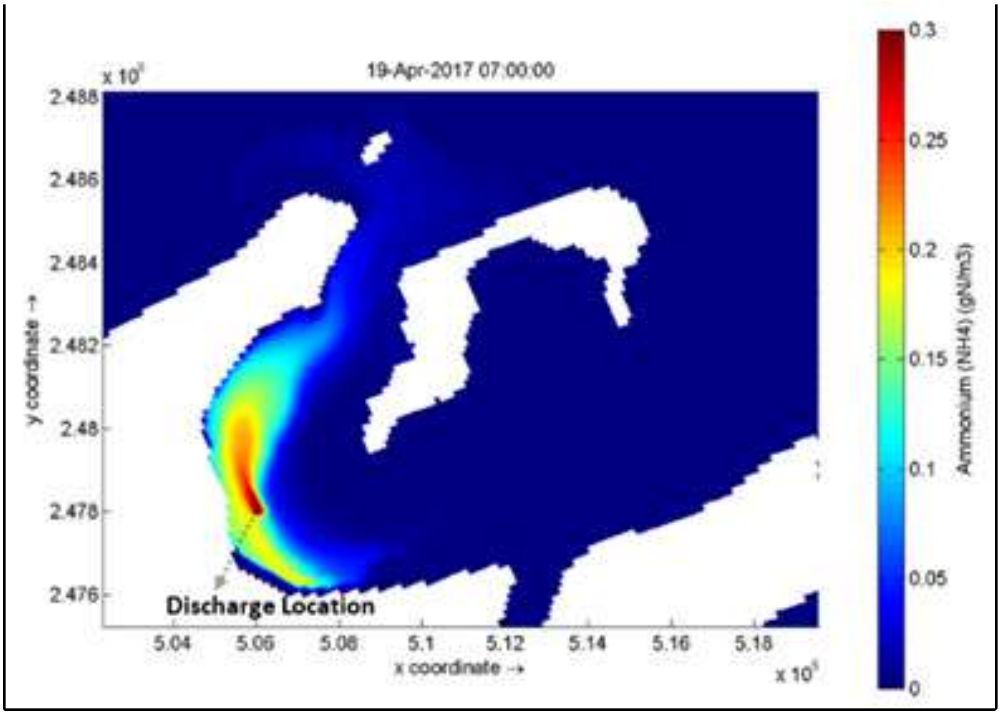


Figure 4-43: Concentration of the ammonia in g/m³ during neap tide peak flood tide

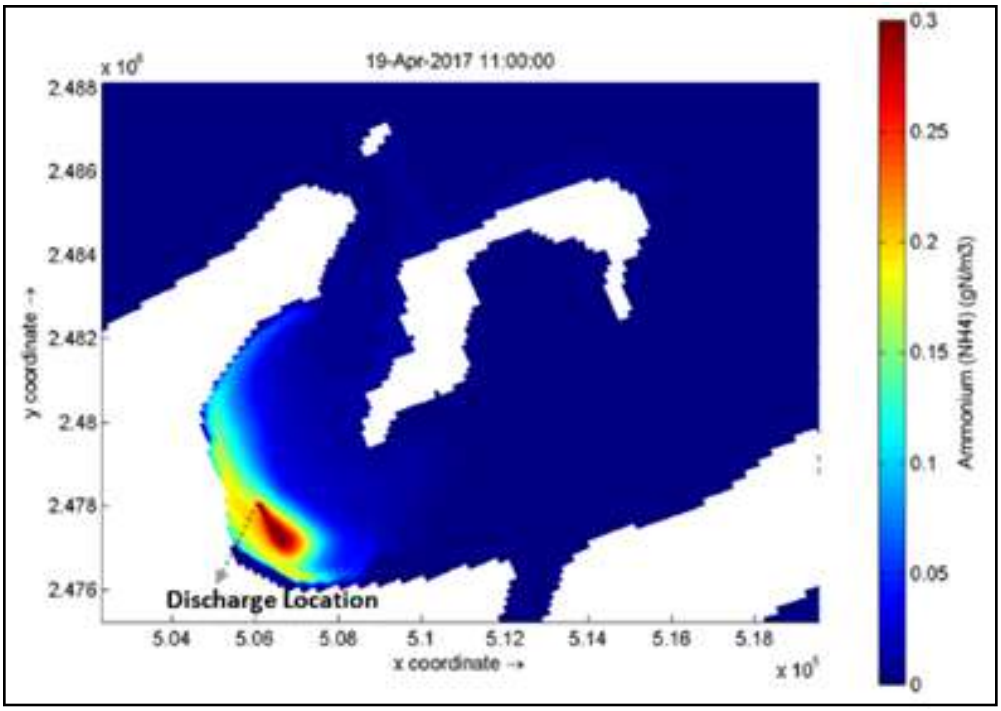


Figure 4-44: Concentration of the ammonia in g/m³ at the end of neap tide cycle

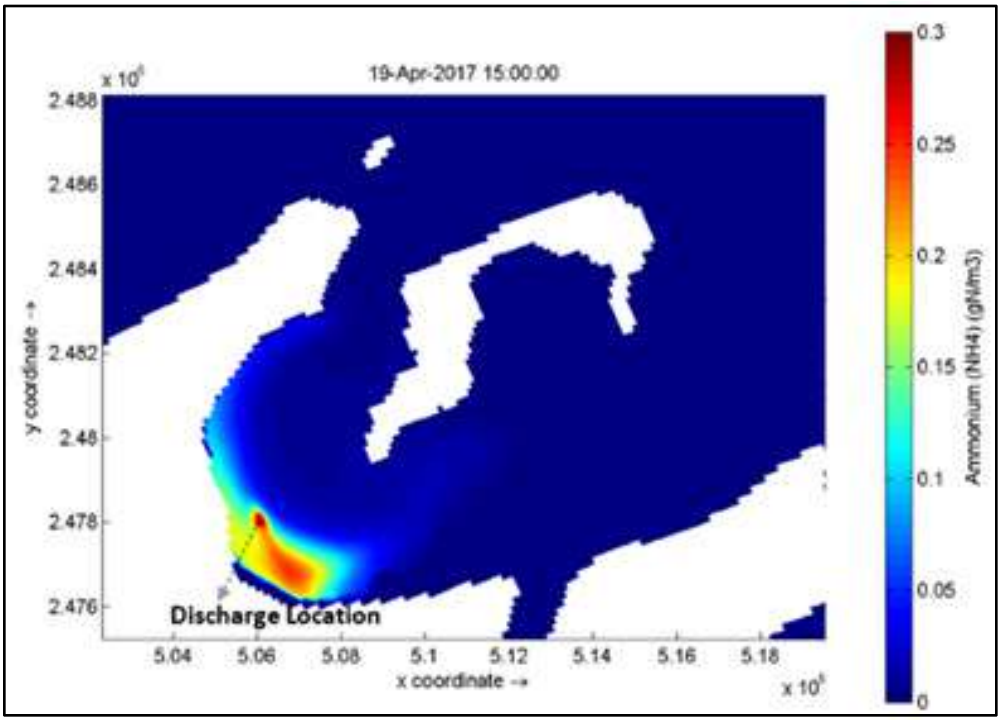


Figure 4-45: Variation of ammonia at 300 m from the outfall point for prescribed characteristics of the treated waste water

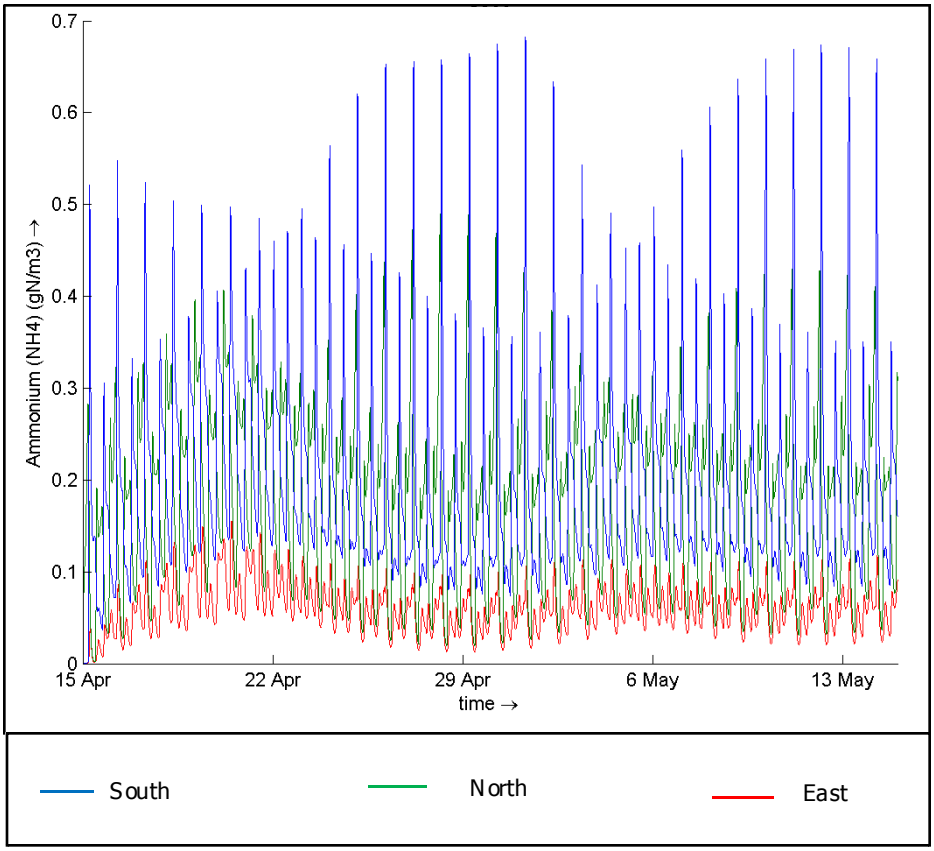


Figure 4-46: Variation of ammonia at 600 m from the outfall point for prescribed characteristics of the treated waste water

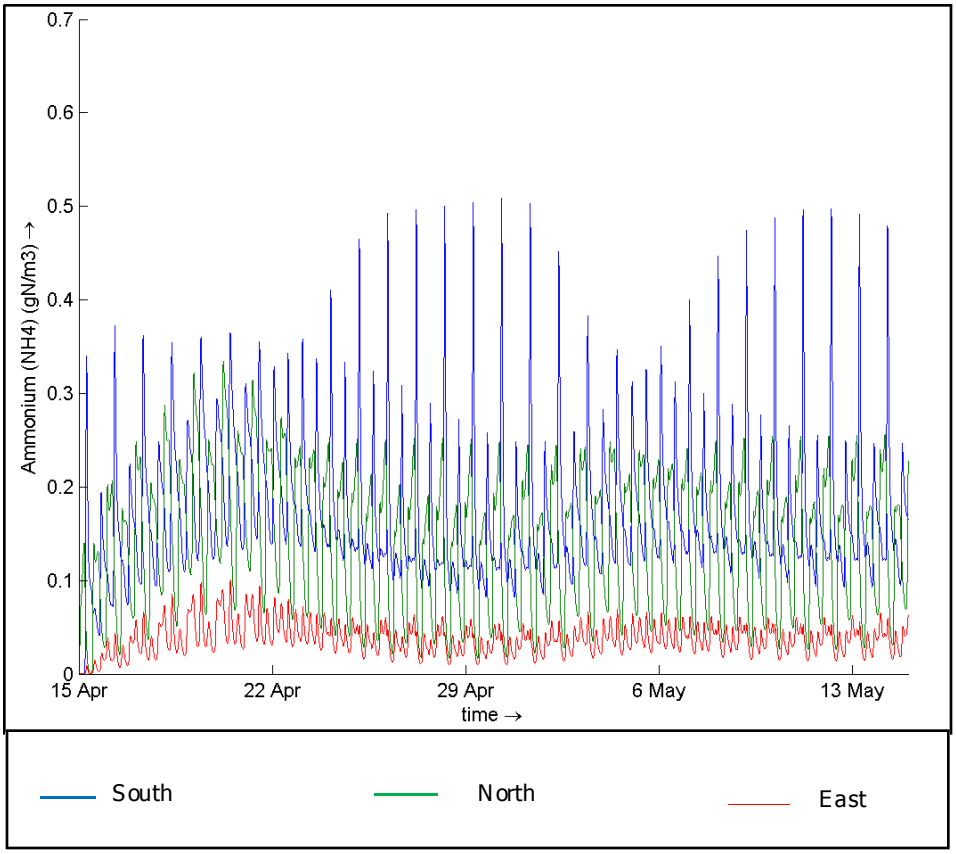


Figure 4-47: Variation of ammonia at 1000 m from the outfall point for prescribed characteristics of the treated waste water

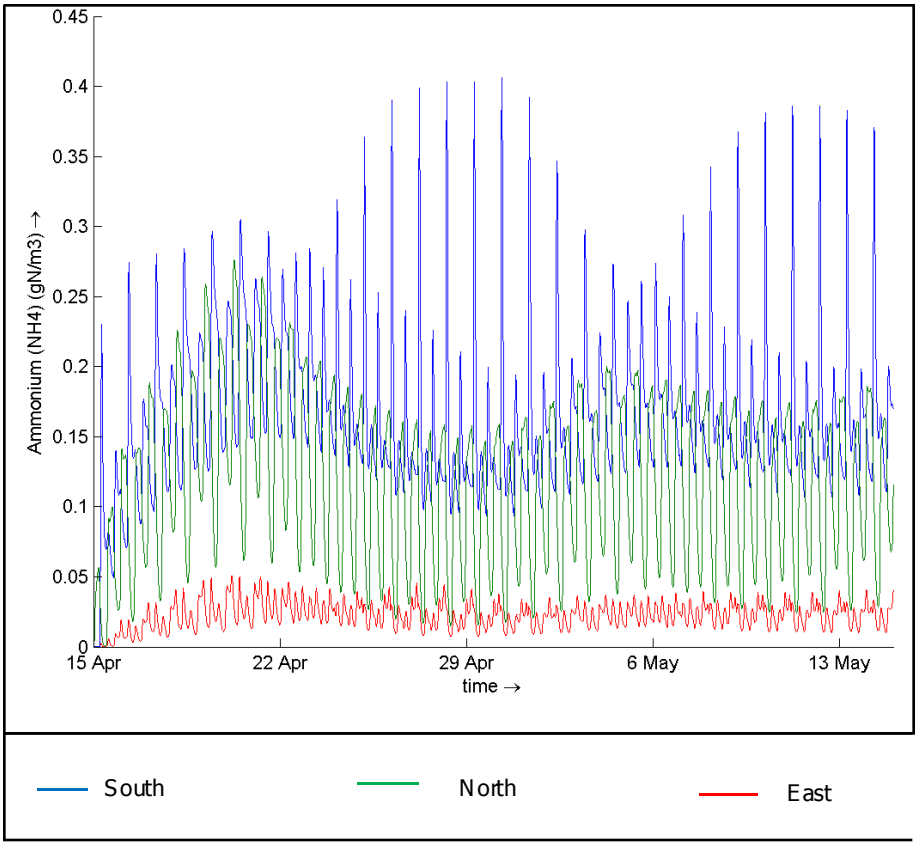


Figure 4-48: Variation of Ammonia concentration at 300 m from the outfall for observed conditions

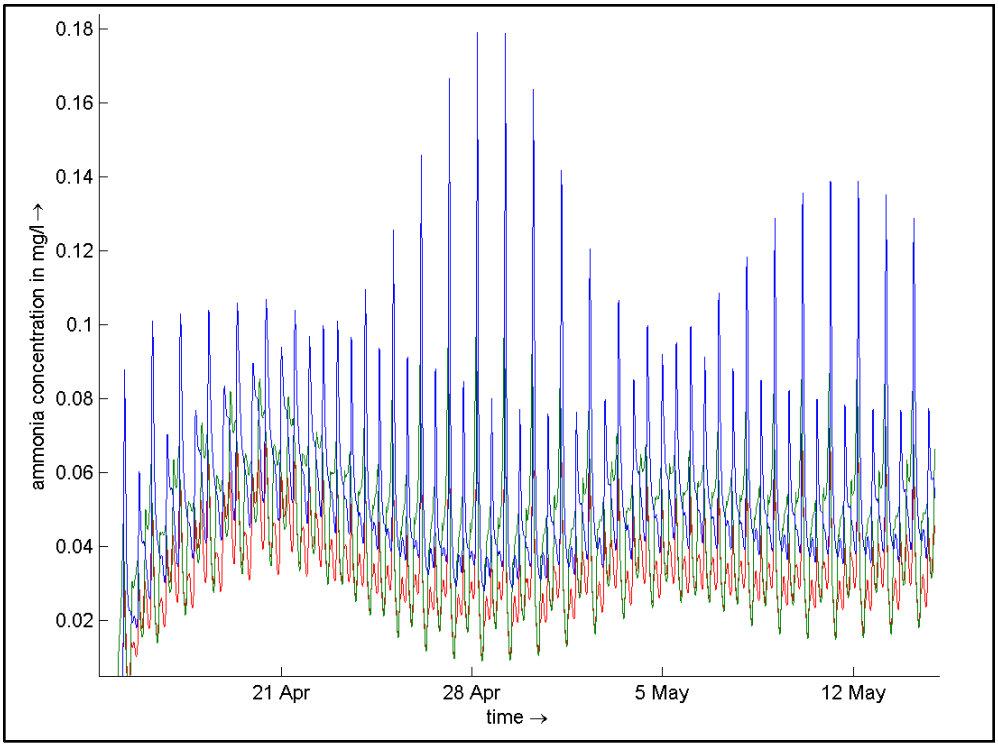


Figure 4-49: Variation of Ammonia concentration at 600 m from the outfall for observed conditions

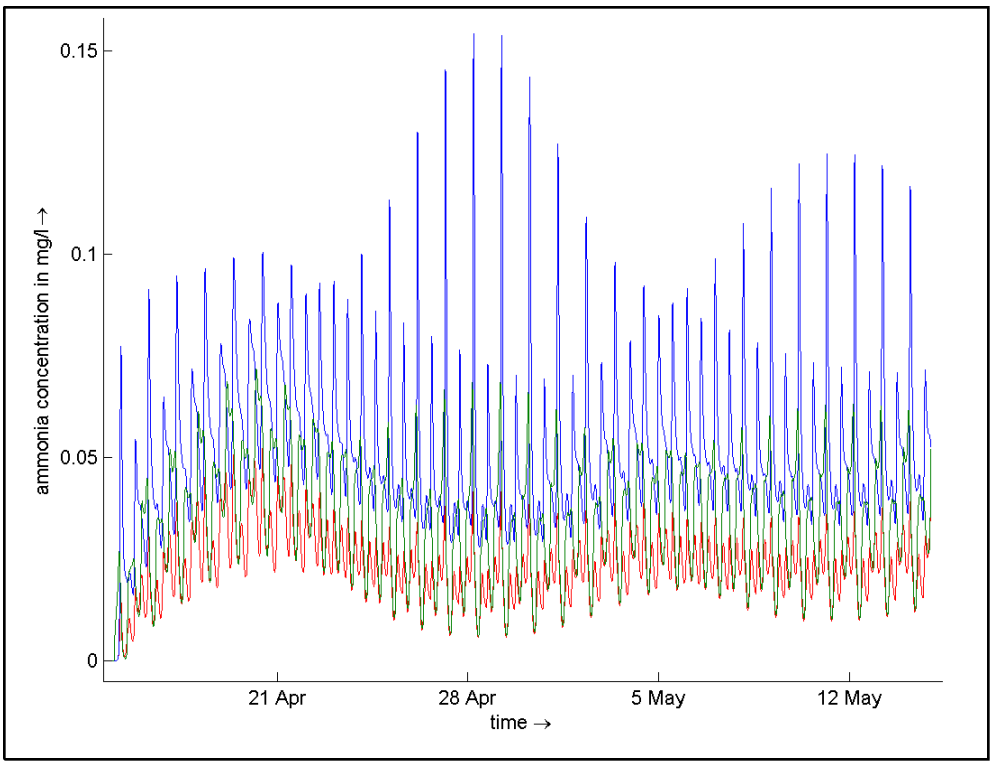
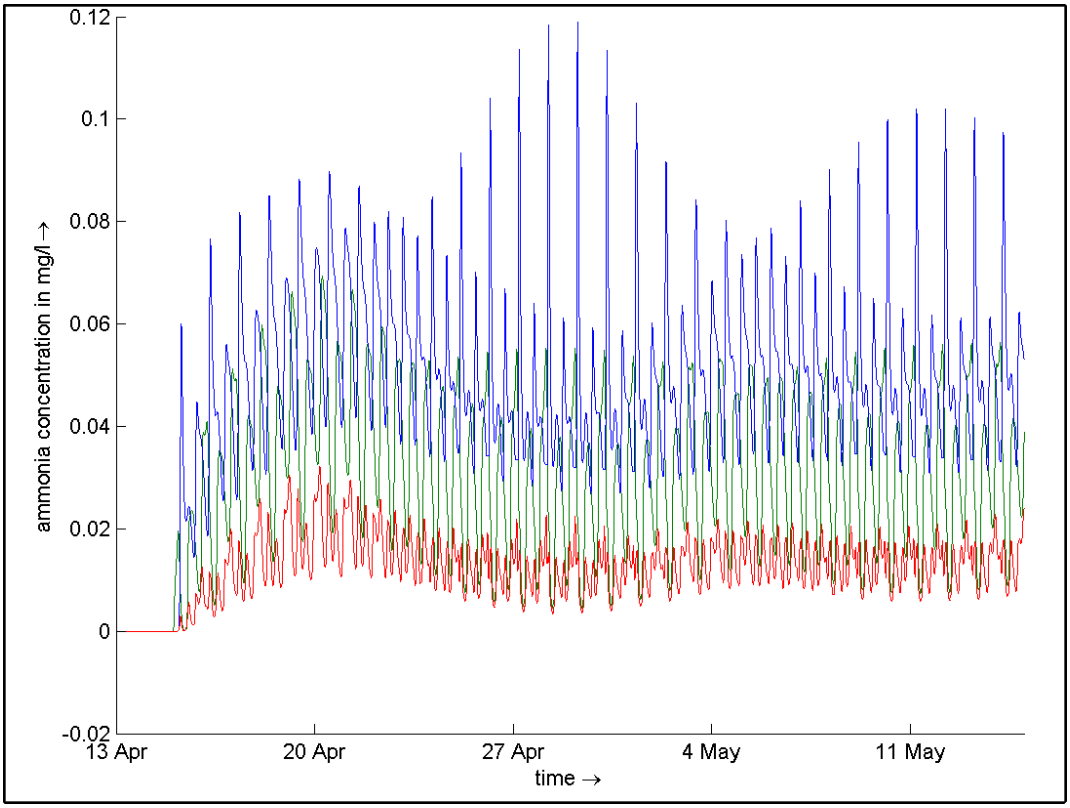


Figure 4-50: Variation of Ammonia concentration at 1000 m from the outfall for observed conditions



5 SUMMARY & CONCLUSIONS

- Numerical model study was conducted to estimate the effect of the discharged treated waste water into the sea at Mithapur Bay.
- Temperature, suspended sediment concentrations and Ammonical Nitrogen were the parameters studied as part of the study. The study gives the maximum possible changes observed in these constituents in the surrounding waters due to the discharge of treated waste water.
- A two-stage hydrodynamic model was setup as part of the study. Effects of the advection and dispersion characteristics of the flow on the parameters were studied.
- The peak average magnitudes of currents at the location of discharge are in the order of 0.33 m/sec and 0.27 m/sec during spring tides and 0.15 m/sec and 0.22 m/sec during neap tides.
- The results show that there is no cumulative increase in the temperature in the surrounding areas. The rise and fall of temperature follow the tidal variations, indicating good flushing properties in the area of interest.
- Due to the fact that the current velocities are greater during flood than that during ebb period, the current advents the diluted temperature plume and sediment plume towards the shore south of the location of discharge. The temperature and concentration plumes have higher magnitudes and extents in the area south to the discharge location when compared with the area north of the discharge location.
- For GPCB prescribed characteristics of the treated waste water, the maximum increase in the suspended sediment concentration values at a distance of 1000 m in the south, north and east directions to the discharge location is around 40 mg/l, 27 mg/l and 5 mg/l respectively. The maximum increase in the temperature values at a distance of 1000m in the south, north and east directions to the discharge location is around 0.7 °C, 0.5 °C and 0.2 °C respectively. The maximum increase in the ammonia concentration values at a distance of 1000m in the south, north and east directions to the discharge location is around 0.4 mg/l, 0.27 mg/l and 0.05 mg/l respectively.
- For field observed characteristics of the treated waste water, the maximum increase in the suspended sediment concentration values at a distance of 1000 m in the south, north and east directions to the discharge location is around 11 mg/l, 6.0 mg/l and 1.0 mg/l respectively. The maximum increase in the temperature values at a distance of 1000m in the south, north and east directions to the discharge location is around 0.23 °C, 0.12 °C and 0.05 °C respectively. The maximum increase in the ammonia concentration values at a distance of 1000 m in the south, north and east directions to the discharge location is around 0.12 mg/l, 0.07 mg/l and 0.03 mg/l respectively.
- These peak concentration values are visible during 10 instances in a month and in each instance the concentration values reach these peak values and return to the ambient concentrations within 2 hours. As these changes are periodic and maintain the same pattern even after a month of simulation it can be concluded that there is no accumulation of treated waste water in the surrounding areas.
- The increase in temperature and suspended sediment concentrations is negligible in the eastern direction and is negligible beyond 1200 m from the treated waste water location of treated waste water discharge. The treated waste water doesn't seem to cause any significant increase in ambient temperature, suspended sediment and ammonia concentration near Beyt Dwarka. Any increase in the surroundings of Beyt Dwarka is limited to 0.05 °C in the case of temperature, 1.0

mg/l in the case of suspended sediment and 0.03 mg/l in the case of ammonia which are negligible.

- Considering the above facts, it can be conduded that the changes in the ambient conditions of the surrounding sea water due to discharge of treated waste water is marginal and are localized both spatially and temporally.

Kadam

Environmental Consultants

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Environment for Development

CONTACT DETAILS

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Annexure - 5

Impact of the Proposed Expansion on Marine National Park and Marine Sanctuary and its ESZ

Study on Impact on Biodiversity

Impact on Biodiversity has been studied and mitigation measures has also been proposed. The same has been given in Wildlife Conservation Plan; which is duly certified by CWW, Gujarat *vide* letter no. WLP/32/C/144-45/2018-19 dated 19th June, 2018. Anticipated impacts, Proposed Conservation Actions and Financial layout for conservation activities are given below:

5 Potential impacts &Mitigations

5.1 Environmental Impacts and Mitigation Measures

Theproject activities for expansion of Soda Ash, Cement and Captive Cogeneration Power Plant areproposed within the existing unit of Tata Chemicals Limited, Mithapur(Gujarat).Anticipated environmental impacts due to the proposed project along with mitigation measures are given in Table below:

Table 5.1 Anticipated Environmental Impacts and Mitigation Measures

Discipline	Impact	Mitigation Measures
Construction Phase		
Air	Emission of Particulate Matter and fugitive dust	• Proper upkeep and maintenance of vehicles. • Sprinkling of water on construction site. • Sufficient greenbelt to suppress particulate emissions outside the plant boundary which will be further developed & maintained.
Water	Surface Run-off during rainy season	• An adequate drainage system & storm water drains for run-off water
Noise	Increase in the noise level	• The impact is temporary in nature. • To avoid impact on the workers, personal protective equipments such as ear muffs should be provided
Soil	Generation of Solid Earth waste	• Recycling of most of the solid earth waste for levelling of uneven terrain within the plant premises and colony
Operation Phase		
Air	Emission of particulate matter and gaseous emissions	• Operation of Air Pollution Control Devices • Adequate stack height for proper dispersion of air pollutants • NH3 recovery system to avoid NH3emission in the air • Limestone dust addition (Desulphurization) to the fuel (petcoke) in boiler to reduce the Sulphur dioxide emissions to atmosphere • Dust collection system at transfer points • Bag filters at dry fly ash handling area • Regular sweeping and sprinkling of water on roads to avoid dust
Water	Discharge of Treated waste water	• Quantity of treated waste water shall be within existing limit of 240,000 M3/day • Treated waste water shall meet the prescribed norms. • Proper treatment of wastewater before its discharge into the Sea- Recovery of

Discipline	Impact	Mitigation Measures
		ammonia, filtration and sedimentation of solids areused to treat waste water from the plant before it is discharged into Arabian sea. • STP has been provided for domestic waste water from the colony.
Noise	Increase in noise level within the plant area	• Enclosures/padding to the high noise generating machineries • Development of Greenbelt in and around the plant site. • Ear plugs for persons working in high noise zones.

Impacts of proposed activities on flora and fauna of surrounding area identified by using information presented in previous Chapter-4. The impacts on various components of biodiversity were assessed. The component wise identification of potential impacts and Mitigation Measuresare deliberated below:

Table 5.2 Component wise Impact assessment and Mitigation Measures

S. No.	Component	Impact		Mitigation
		Core Zone (Project site)	Buffer zone (10 Km study area)	
1	Flora Mangroves	No vegetation is to be removed due to project activities. The expansion activities will be carried out within the existing TCL complex.	No vegetation/ mangrove plantation is to be removed due to project activities.	Maintain the regulatory stipulated standards for treated waste water, Air emissions & solid waste management. New planation is to be developed within and outside plant area.
2	Fauna Reptiles Seaturtles Birds Mammals Coral Reef	The expansion activities will be carried out within the existing TCL complex.	No additional activities are proposed in buffer zone.	Quantity of treated waste water shall be within existing limit of 240,000 M3/day Treated waste water shall meet the prescribed norms.

Table 5-3: General Impacts vs. mitigation matrix.

Issues		Reason/Status in relation to project site	Suggestions	Reference/method
Species	Rare/Endangered /Threatened species	Not reported in the core area i.e. TCL complex. However, Green Seaturtle and Olive Ridley are reported to be present in the study area.	The expansion is proposed within existing TCL complex (core zone) and TCL shall install & operate all pollution control devices committed in EIA study for control of pollution at source. Maintain GPCB/CPCB standards for release of pollutants from different sources.	Field observation, interview of local naturalists& people. Information available in public domain. Sunderraj *et al* 2002
	Endemic Species	No endemic species of any flora, fauna or wildlife present in and around project site	Nil	Field survey, Literature review
Important Natural Habitats	Protected Areas and Ecosensitive zones (ESZ)	Part of Marine National Park and Marine Sanctuary and its ESZ area falls within Buffer zone. Project site (core zone) falls outside the protected area and its ESZ	The expansion is proposedwithin existing TCL complex (core zone) and TCL shall install & operate all pollution control devices committed in EIA study for control of pollution at source. TCL to support local forest department, NGO for awareness and welfare activities on marine environment conservation within study area.	Government of Gujarat protected area website, Project Maps etc.
	Mangroves	Mangroves are present on the coast in the Marine Sanctuary area falls within Buffer zone. No mangrove plantation is to be removed due to project activities. Project site (core zone) falls outside the mangrove areas	The expansion is proposedwithin existing TCL complex (core zone) and TCL shall install & operate all pollution control devices committed in EIA study for control of pollution at source. Maintain GPCB/CPCB standards for release of pollutants from different sources Take up mangrove conservation, awareness, and plantation activities with forest department or NGOs.	Mangrove Atlas by Gujarat Ecology Commission, Project Maps etc.
	Coral Reef	Coral reef of Marine National Park located at Mithapur Reef on Arabian Sea coast and Arambhda group of islands falls within Buffer	The expansion is proposedwithin existing TCL complex and TCL shall install & operate all pollution control devices committed in EIA study for control of pollution at source.	EIA study, Coral Reef Atlas by Gujarat Ecology Commission, Project Maps etc.

	zone Project site (core zone) falls outside Coral Reef area	Maintain GPCB/CPCB standards for release of pollutants from different sources. Assist Forest Department in monitoring coral reef around the Gulf of Kutchh.	
Reserve Forest Areas (Mangrove and Terrestrial)	Reserve Forest Areas (Mangrove and Terrestrial) falls within Buffer zone. Project site (core zone) falls outside Reserve Forest areas (Mangrove and Terrestrial)	The expansion is proposedwithin existing TCL complex and TCL shall install & operate all pollution control devices committed in EIA study for control of pollution at source. Maintain GPCB/CPCB standards for release of pollutants from different sources Take up mangrove conservation, awareness, plantation activities with forest department or NGOs	Consultation with Local Forest officials and Forest Area Map of Jamnagar
Breeding/nesting areas	Some of the Seaturtle nesting areas fall within Buffer zone. Project site (core zone) falls outside Reserve Forest areas (Mangrove and Terrestrial)	Take up awarenessactivities with forest department or NGOs	Literature Survey (Sunderraj et al 2002), Project Map and local maps

- TCl shall implement Environment Management Plan suggested Environment Impact Assessment study.
- TCl shall ensure operation of air pollution control devices as per prescribed norms.
- TCl shall maintain quality of treated waste water as per prescribed norms.

- Awareness and conservation activities for schedule-I species in their ongoing corporate conservation activities in association with reputed NGOs and Gujarat Forest Department.
- A comprehensive survey of status of the wildlife and vegetation shall be carried out at every 5 year for buffer areas in order to evaluate the impacts/cumulative impacts of project activities on the surrounding ecology and wildlife therein.
- TCL shall make substantial financial allocations for carrying out suggested wildlife conservation, education, and awareness activities in the region as part of their ongoing CSR activities.
- Based on review and comments provided by concerned wildlife authorities, the wildlife conservation action plan shall be reviewed at every 5 years.

PROPOSED FINANCIAL LAYOUT FOR WILDLIFE CONSERVATION PLAN

S. No	Activity	Agency	Duration	Amount/ year	Total Amount for 5 years
A. Conservation & Awareness Activities					
1.	Mangrove plantation every year for 5 years	Forest Dept.	5 years only	6 Lakh	30.0 Lakh
2.	Conservation and awareness activities for endangered wildlife species found in Gulf of Kachchh & surrounding area (Seaturtles, whale shark etc.)	TCL / NGO/ Forest Dept.	5 years (review after years)	2.0 Lakh	10.0 Lakh
B. Ecological Monitoring Activities					
1.	Monitoring & status survey of wildlife, mangroves in core and buffer areas	Company	Once Every 2 year for 6 years	2.0 Lakh	6.0 Lakh
C. Compliance reporting					
1.	Compliance documentation and Reporting to MoEF & Forest Dept.	Company	Once every year for 5 years	1.0 Lakh	5.0 Lakh
D. Total Amount					51.0 Lakh

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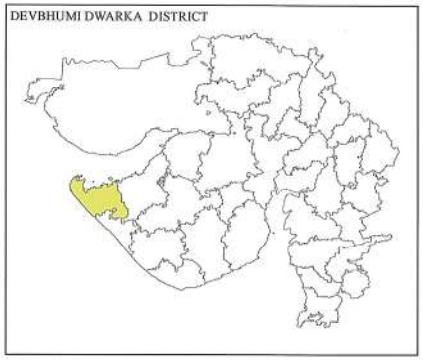
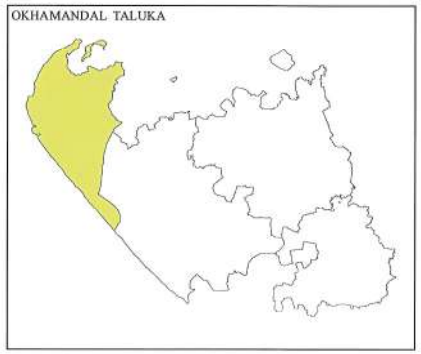
LOCATION MAP





No.	Co-ordinates
A	22°24'51.92"N 69° 0'48.59"E
B	22°25'55.16"N 68°59'33.69"E
C	22°25'44.38"N 68°59'31.89"E
D	22°24'17.46"N 69° 1'16.27"E
E	22°24'18.74"N 69° 2'8.69"E
F	22°24'20.75"N 69° 2'43.44"E

KEY

- 5 KM BUFFER
- 10 KM BUFFER
- VILLAGE LINE
- REVENUE SURVEY NUMBER
- ECO-SENSITIVE ZONE LAND SIDE 1 KM
- ECO-SENSITIVE ZONE SEA SIDE 200 M
- SPARSH CORAL
- SEA
- RIVER / WATERBODY
- SITE PLOT
- MARINE SANCTUARY AREA
- MARINE NATIONAL PARK
- FOREST
- RAILWAY
- NATIONAL HGHWAY
- STATE HIGHWAY
- DISTRICT ROAD
- VILLAGE ROAD

1 centimeter = 445 meters

M/S. TATA CHEMICALS LTD.
TOPO SHEET NO : 41 F 03,
VILLAGE: SURAJ KARADI,
TALUKA : OKHAMANDAL
DISTRICT : DEVBHUMI DWARKA

0 1.5 3 6 9 km

No: - WLP/32/C/ 144-45 /2018-19

Office of the
Principal Chief Conservator of Forests,
Block No.B, "Aranya Bhavan",
Ch-3 Circle, Sector-10 A,
Gujarat State, Gandhinagar.
Date: - 19 /06/2018.

To,
M/s Tata Chemicals Ltd.
Village(s) Mithapur & Surajkaradi,
Taluka Dwarka, District Dwarka,
Gujarat

Sub. :- Expansion of cement production capacity from 7,87,000 TPA to 9,00,000 TPA by M/s Tata Chemicals Ltd. located at Village(s) Mithapur & Surajkaradi, Taluka Dwarka, District Dwarka, Gujarat – prescribing of ToRs regarding.

Ref:- 1. Ministry of Environment, Forest and Climate Change (Impact Assessment Division), Government of India's letter F.No. J-11011/140/2016-IA.II (1) dt.02-08-2016
2. Ministry of Environment, Forest and Climate Change (Impact Assessment Division), Government of India's letter F.No. J-11011/66/1999-IA.II (1) dt.10-01-2017
3. M/s Tata Chemicals Ltd District, Dwarka, Gujarat, letter dated 20-07-2017
4. Chief conservator of Forest Marine National Park Jamnagar no : A/LND/ T-9/ 153/ dt. 29-05-2018

With reference to the subject and letters quoted above, the Wildlife Conservation Plan July-2017 prepared by Bhagwati Enter care Private Ltd for the Project mentioned in the subject of Rs. 51,00,000/- (Fifty one lakh only) has been approved. A copy of the Wildlife Conservation Plan is enclosed herewith.

Encle : As above

(G.K. Sinha)
Chief Wildlife Warden,
Gujarat State, Gandhinagar

Copy to: - The Chief Conservator of Forest, Marine National Park Jamnagar for information.

Water Requirement

Water Requirement for Soda Ash and Captive Cogeneration Power Plant

a) **Fresh Water Requirement:** The existing fresh water requirement for Soda Ash and Captive Cogeneration Power Plant is 7,100 m^3/ day; which is being sourced from Rain Water Lake.

No additional fresh water will be required for the proposed expansion project.

b) **Sea Water Requirement:** The existing sea water requirement for soda ash, captive co-generation power plant and other associated activities is 2,45,824 m^3/day; which is being sourced from Arabian Sea. Additional sea water requirement for the proposed expansion of Soda Ash & Captive Cogeneration Power Plant is 30,872 m^3/day.

Thus, the total sea water requirement after proposed expansion will be 2,76,696 m^3/ day. The same will be sourced from existing sea water intake facility (Arabian Sea).

Break - up of water requirement is given in table below:

Table - 1

S. No.	Particulars	Plant	Requirement (m^3/ day)			Source
			Existing	Additional	Total after expansion	
1.	Fresh Water	For Industrial process	5,900	--	5,900	Rain Water Lake
		For Domestic Use	1200	--	1200	
		TOTAL	7,100	--	7,100	
2.	Sea Water	Soda Ash	1,44,387	22,872	1,67,259	Arabian Sea
		Captive Cogeneration Power Plant	67,200	--	67,200	
		RO Plant	12,000	8,000	20,000	
		Others (if any)	22,237	--	22,237	
		TOTAL	2,45,824	30,872	2,76,696	

Water Requirement for Cement Plant

Details of the existing and proposed water requirement along with source are given in the table below-

Table - 2

Water Requirement- Cement Plant

S. No.	Particulars	Requirement (m^3/ day)			Source
		Existing	Additional	Total after expansion	
1.	Raw Water	562	260	822	Existing Sea Water Desalination Units
2.	Sea Water	897	223	1120	Arabian Sea

Water Balance Diagram

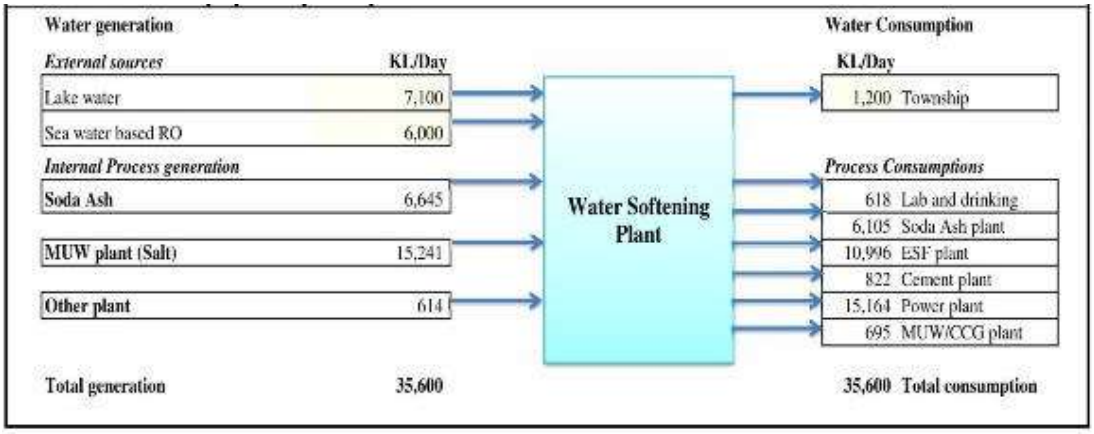


Figure 1 - Sweet Water Balance Diagram
(total requirement after proposed expansion including cement plant)

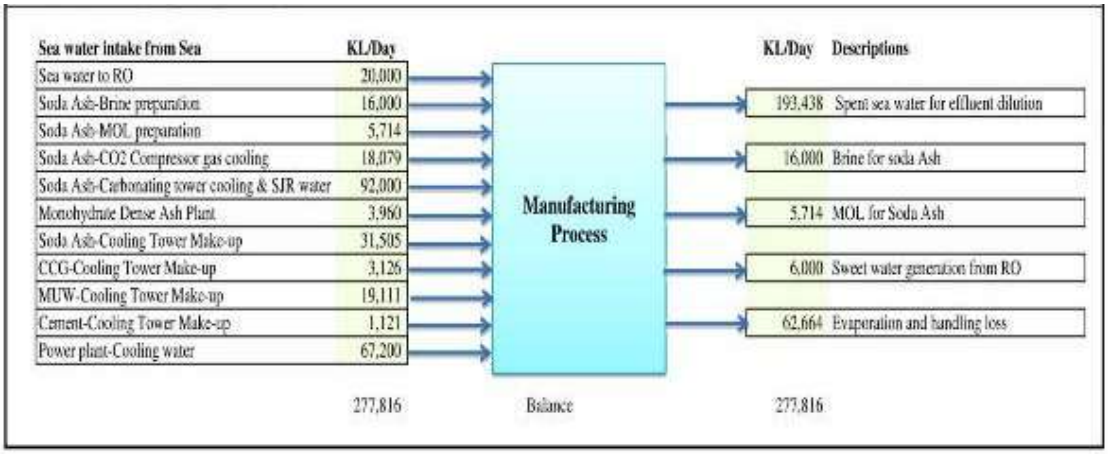


Figure 2 - Sea Water Balance Diagram
(total requirement after proposed expansion including cement plant)

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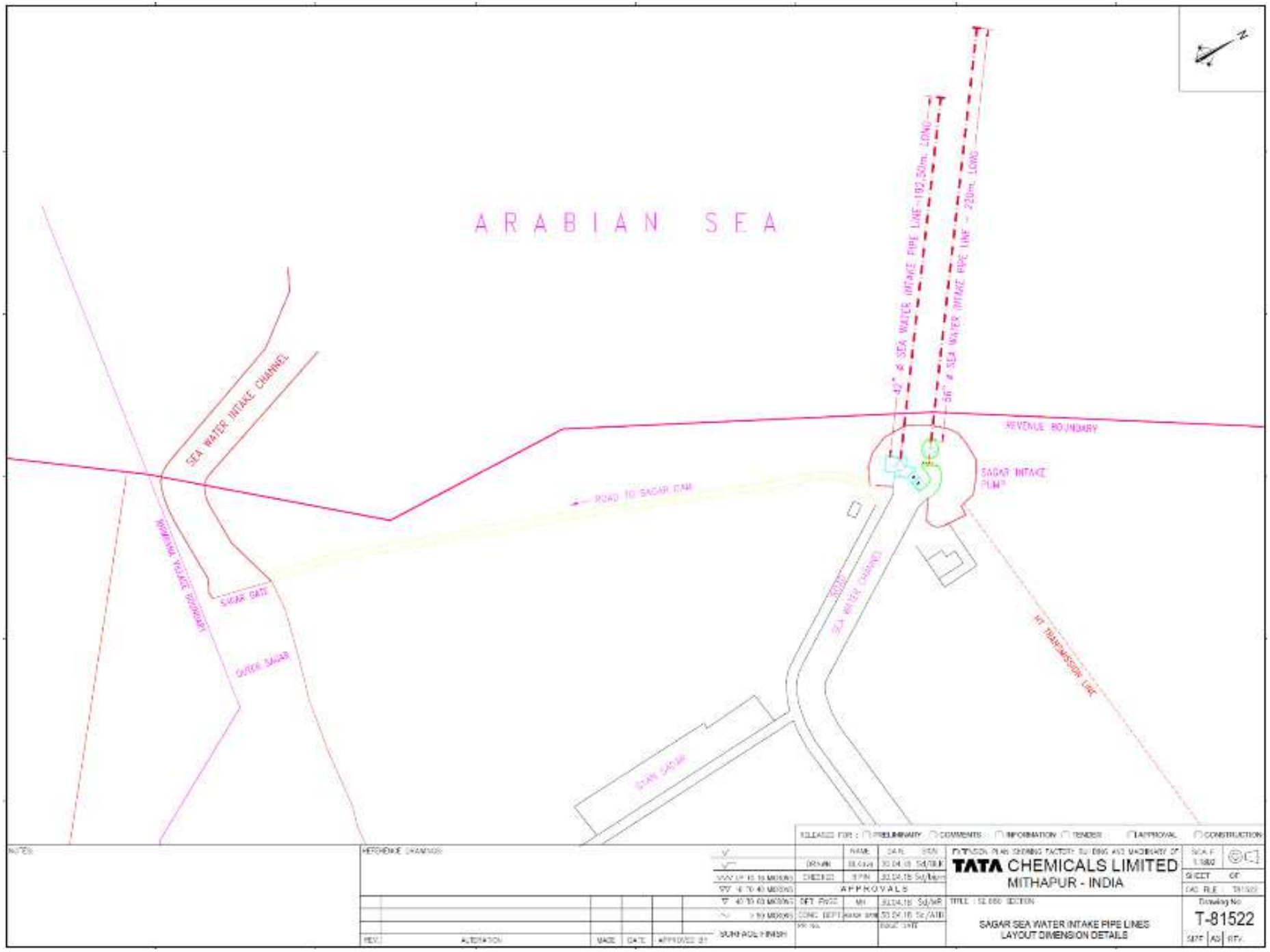
Existing Sea Water Intake System

Existing Sea Water Intake System



F.No.11-34/2016-IA-III
Government of India
Ministry of Environment, Forest and Climate Change
(IA.III Section)

Indira Paryavaran Bhawan,
Jor Bagh Road, New Delhi - 110003
Dated: 10 July, 2017

To,

The Director
M/s Tata Chemicals Limited
District Devbhumi, Dwarka
Gujarat -361335

Sub: Pipeline and Diffuser System for Disposal of Treated waste water at Marine outfall point at District Devbhumi, Dwarka, Gujarat - CRZ Clearance - reg.

Sir,

This has reference to your proposal No. IA/GJ/MIS/59359/2016, dated 30.09.2016 received in this Ministry for CRZ Clearance in accordance with the provisions of the Coastal Regulation Zone (CRZ) Notification, 2011 issued under the Environment (Protection) Act, 1986.

2. The proposal has been considered by the Expert Appraisal Committee (EAC)- Infrastructure Development, Coastal Regulation Zone, Building / Construction and Miscellaneous projects, in its 165th and 170th meetings held during January 16-17, 2017 and May 11, 2017 respectively. The details of the project, as per the documents submitted by you and as informed during the aforesaid meetings of the EAC are noted as under:

(i) The project involves laying of treated effluent disposal pipeline from their plant to final disposal point in the Gulf of Kutch at Mithapur in Gujarat, in lieu of the existing system of conveyance through open channel disposal of treated waste water discharge. The proposed project involves installation of trestle mounted pipelines and diffuser system to the marine outfall point suggested by NIO, which shall be beyond Marine Sanctuary and its Eco-sensitive zone.

(ii) The total length of proposed treated waste water disposal pipeline corridor is 3756 m. The length of pipeline in Non CRZ area is 318.75 m and the length of pipeline in CRZ area is 3437.25 m.

(iii) Waste water generation, treatment and disposal: Treated waste water of 240,000 KLD will be disposed off through the proposed system.

(iv) Municipal solid waste generated disposal facility: There will not be municipal solid waste generation due to this improvement proposal.

(v) Power requirement and source: Power Requirement: 2x 1250 KW (1 Working+01 Stand By Pump), 3.3 KV, which will be sourced TCL Captive supply.

(vi) Investment/Cost of the project: Rs. 229 Crores.

(vii) Wildlife issues: Yes, The proposed pipeline corridor in parts would pass through Marine sanctuary.

(viii) The project lies within 10 kms of an Eco Sensitive Zone area.

(ix) Details of Forest land: About 11.268 ha of mangrove forests will be involved. This extent of an area has also been declared a mangrove forest as per Draft notification No. GVN/1999(8)/JJM/1692/1652/K. Settlement order No. K/FSO/T-3/1548/2013-14 of FSO, Junagadh, dated 11/05/2013, which are yet to be finalized by Government of Gujarat.

(x) Approval for the proposed project by the NBWL has been recommended in the 39th Meeting, dated 23rd August, 2016.

(xi) CRZ demarcation has been conducted by Institute of Remote Sensing (IRS), Anna University Chennai.

(xii) SCZMA Recommendations: Gujarat Coastal Zone Management Authority has recommended the proposal from CRZ perspective vide its letter dated 28.06.2016.

3. The proposal has been recommended for CRZ Clearance by the Expert Appraisal Committee (EAC) in the Ministry for Infrastructure Development, Coastal Regulation Zone, Building/ Construction and Miscellaneous projects, in its 170th meeting held during May 11, 2017. Based on the information submitted by you as at para no. 2 above and others and information made during the presentation before the EAC, the Ministry of Environment, Forest and Climate Change hereby accords CRZ Clearance to the above project viz *'Pipeline and Diffuser System for Disposal of Treated waste water at Marine outfall point at District Devbhumi, Dwarka, Gujarat'* under the provisions of the CRZ Notification, 2011 and amendments thereto and circulars issued thereon, and subject to the compliance of the following specific and general conditions as under:

PART A – SPECIFIC CONDITIONS:

(i) All conditions/recommendations stipulated by the Gujarat Coastal Zone Management Authority (GCZMA) vide its letter no. ENV-10-2016-74-E(T Cell), dated 28.06.2016 shall strictly be complied with.

(ii) The clearance is subject to obtaining prior approval of the Standing Committee of the National Board of Wildlife, under Wildlife (Protection) Act, 1972, before commencement of work.

(iii) The clearance is also subject to obtaining prior approval for diversion of forest land (mangrove) as may be applicable, under Forests (Conservation) Act, 1980, before commencement of work.

(iv) A 2% of the cost of the project shall be apportioned for marine and coastal biodiversity protection and conservation measures, to be spent by the project proponent towards fulfilling its Corporate Environmental Responsibility (CER) during the currency of the project. Proper record and account of measures taken should be maintained and should also be submitted to the CZMA every six months.

(v) 'Consent to Establish' shall be obtained from State Pollution Control Board under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.

(vi) The construction in CRZ areas shall strictly in accordance with the provisions of CRZ Notification, 2011 and as amended from time to time.

(vii) There shall be no dressing or alteration of the sand dunes, natural features including landscape changes for beautification, recreation and other such purpose.

(viii) All waste (liquid and solid) arising from the proposed development will be disposed off as per the norms prescribed by State Pollution Control Board. There shall not be any disposal of untreated effluent in to the sea/coastal water bodies.

(ix) Installation of the Sewage Treatment Plant should be certified by an independent expert and a report in this regard should be submitted to the Ministry before the project is commissioned for operation. Treated effluent emanating from STP shall be recycled/ reused to the maximum extent possible. Treatment of 100% grey water by decentralized treatment should be done. Discharge of unused treated affluent shall conform to the norms and standards of the State Pollution Control Board. Necessary measures should be made to mitigate the odour problem from STP.

(x) The project proponent shall ensure that no ground water drawal is carried out within CRZ areas without prior approval of the Central Ground Water Authority. It shall also be ensured that untreated wastewater is not discharged outside the project premises. Wastewater generated shall be treated in STP and is reused for landscaping, flushing and HVAC cooling purposes. The project proponent should also make alternate arrangement for situation arising due to malfunctioning of STP. There shall be regular monitoring of the results of standard parameters of the effluent discharged from STP under intimation to the SPCB.

(xi) Soil and ground water samples will be tested to ascertain that there is no threat to ground water quality by leaching of heavy metals and other toxic contaminants.

(xii) Disposal of muck during construction phase should not create any adverse effect on the neighbouring communities and be disposed taking the necessary precautions for general safety and health aspects of people, only in approved sites with the approval of competent authority.

(xiii) Any hazardous waste generated during construction phase, should be disposed off as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

(xiv) Solid waste management shall be collected, treated disposed in accordance with the Solid Waste Management Rules, 2016.

(xv) As part of CSR activity, the project proponent shall identify schemes on need based assessment and implemented in select villages in the project area in consultation with the village Panchayat and the District Administration. Separate budget for community development activities and income generating programmes shall be earmarked.

(xvi) The pipeline shall be laid on trestles to minimise impact on sea bed and aquatic life.

(xvii) Storage of raw material and camp with sanitation facilities for the construction labour shall be set up beyond sanctuary limits.

(xviii) Treated waste water conforming to GPCB norms shall only be discharged; it shall be ensure that regular monitoring results of the treated waste water discharge conducted by an independent agency shall be submitted to the GPCB and the regional office of Ministry.

(xix) As committed by the project proponent, a comprehensive survey of the wildlife and vegetation shall be carried out at every 5 year in buffer areas and shall be submitted to concerned authority.

(xx) Mudflat restoration plan with specific focus on waders and other waterbirds of the affected region be developed and implemented through concerned authority.

(xxi) Baseline for Marine and coastal biodiversity of Poshitra Bay should be developed and monitored bi-annually with specific focus on sea grass beds, and endemic species *Sakuraeolis gujaratica* and *Anteaeolidiella poshitra*. The data shall be submitted to the regional office of the Ministry and the concerned agency in the State.

PART – B: GENERAL CONDITIONS

(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.

(ii) Full support shall be extended to the officers of this Ministry/Regional Office by the project proponent during inspection of the project implementation by furnishing requisite documents/data sought and action taken reports in respect of mitigation measures and other environmental protection activities required to be implemented.

(iii) 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.

(iv) 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.

(v) In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry.

4. Concealing factual data or submission of false/fabricated data and failure to comply with any of the conditions mentioned above may result in withdrawal of this clearance and attract action under the provisions of Environment (Protection) Act, 1986.

5. The above stipulations would be enforced among others under the provisions of the 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, the EIA Notification, 2006 and the CRZ Notification, 2011.

6. The Ministry reserves the right to add additional safeguard measures subsequently, if found necessary, and to take action including revoking of the environment clearance under the provisions of the Environmental (Protection) Act, 1986, to ensure effective implementation of the suggested safeguard measures in a time bound and satisfactory manner.

7. All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.

8. The project proponent should 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 (SPCB) and may also be seen on the website of the Ministry of Environment, Forest and 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 concerned Regional Office of this Ministry.

9. 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.

10. Any appeal against this clearance shall lie with the National Green Tribunal, Western Zone, at Pune, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.

11. A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad/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.

14. The proponent shall upload the status of compliance of the stipulated 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&CC, the respective Zonal Office of CPCB and the SPCB. The criteria pollutant levels namely SPM, RSPM, SO_2, NOx (ambient levels as well as stack emissions) or critical sectoral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.

12. 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 conditions and shall also be sent to the respective Regional Office of the Ministry by e-mail.

(**Arvind Kumar Nautiyal**)
Director

Copy to:

1. The Secretary, Department of Forests & Environment, Block 14, 8th floor, Sachivalaya, Gandhinagar - 382 010 Gujarat.
2. The Chairman, (Environment) & Additional Secretary Department of Forest and Environment Gujarat Coastal Zone Management Authority Government of Gujarat Block No.14/8th Floor, New Sachivalaya Sector-10 A, Gandhinagar
3. The Chairman, CPCB, Parivesh Bhawan, CBD-cum-Office Complex, East Arjun Nagar, Delhi - 110032
4. The Member Secretary, Gujarat Pollution Control Board, Paryavarana Bhawan Sector-10 A, Gandhinagar-382010
5. The APCCF (C), MoEF&CC Regional Office (WZ),E-5, Kendriya Paryavaran Bhawan, E-5 Arera Colony, Link Road-3, Ravishankar Nagar, Bhopal - 462016
6. Guard File.
7. Monitoring Cell.

(**Arvind Kumar Nautiyal**)
Director

No: WLP/32/B/1913-17 /2017-18

Office of the
Principal Chief Conservator of Forests
Block No.B/1, Aranya Bhavan,
Ch-3 Circle, Sector-10 A,
Gujarat State, Gandhinagar.
Date: 1 /06/2017.

Sub: Permission under Section – 29 of Wildlife (Protection) Act, 1972 for use of 11.2680 ha land of Block No. 25 in Marine Sanctuary for laying of 2504 m. long and 45 m. wide Waste Water Pipeline by Tata Chemicals Ltd. (TCL) – Gujarat.

Ref:

1. Chief Conservator of Forests, Marine National Park Jamnagar's letter No. A/LND/24/T-9/337-38 dated 10-06-2015.
2. Recommendation of the State Board for Wildlife, Gujarat circulated vide this office's letter no. WLP/28/A/1686 dated 27-01-2016.
3. This Office's letter No: WLP/32/A/1740-42 dated 02-02-2016 submitting proposal to Forest & Environment Department, Government of Gujarat.
4. Forest and Environment Department, Government of Gujarat's letter No. VPS/102016-233/W dated 16-02-2016 to the Secretary MoEF&CC.
5. Recommendation of Standing Committee of National Board for Wildlife, circulated vide MoEF&CC, GoI's letter no. F.No. 6-109/2016/WL (39th Meeting) dated 19-09-2016.
6. Recommendation of Standing Committee of National Board for Wildlife, circulated vide MoEF&CC, GoI's letter no. F.No. 6-69/2017/WL (42nd Meeting) dated 30-05-2017.
7. Hon'ble Supreme Court of India's Order dated 05-10-2015 in I.As filed in reference to Writ Petition (Civil) 202/95.

1. A proposal was received vide reference no. 1 above for permission under Section-29 of the Wildlife (Protection) Act, 1972, for use of 11.2680 ha land of Block No. 25 in Marine Sanctuary for laying of 2504 m. long and 45 m. wide Waste Water Pipeline by Tata Chemicals Ltd. (TCL) – Gujarat.

2. The proposal was placed before the State Board for Wildlife (SBWL) in its 10th meeting held on 21-12-2015 for consultation. The SBWL has approved and recommended the proposal in its meeting vide reference no. 2 above with certain conditions.

3. The proposal was sent to Forest and Environment Department, Government of Gujarat vide reference no. 3 above for onward submission to MoEF&CC, GoI. The said proposal was submitted to MoEF&CC, GoI for consideration of Standing Committee of National Board for Wildlife (NBWL) vide reference no. 4 above. The proposal was discussed in 39th meeting of the Standing Committee of NBWL held on 23-08-2016 and in 42nd meeting of the Standing Committee of NBWL held on 15-05-2017, the Standing Committee of NBWL recommended the proposal vide reference no. 5 & 6 above in its meetings with certain conditions respectively as under:

1/3

"After discussions, considering that the activity is planned in compliance of CRZ regulation and environment clearance conditions and involves use of existing channel for making the pipeline subterranean instead of open channel, Standing Committee agreed to recommend the proposal along with the conditions stipulated by State Chief Wildlife Warden."

"After discussions, the Standing Committee decided to recommend the laying of trestle mounted pipeline instead of subterranean for discharge of waste water from the said plant into the sea."

4. Hon'ble Supreme Court of India has passed an order dated 05-10-2015 in reference to different I.As in Writ Petition (Civil) 202/95 vide reference no. 7 above. The order of the Hon'ble Supreme Court of India is reproduced as under:

"All matters for grant of permissions for implementation of projects in areas falling in National parks/sanctuaries, including rationalization of boundaries etc. will be considered by the Standing Committee of the National Board for Wildlife ("NBWL") on its own merits and in conformity with the orders and directions passed by this Court from time to time, i.e. on 14.02.2000, 13.11.2000, 9.5.2002, 16.12.2002,, 25.11.2005 and 14.09.2007 and other subsequent clarificatory orders/judgment(s) passed by this Court including the Goa Foundation Judgment, i.e. Goa Foundation Vs. Union of India & Ors., reported in (2014) 6 SCC 590.
We request the NBWL to furnish a copy of the orders passed by it within 30 days' time to the C.E.C. The C.E.C. is at liberty, if, for any reason, they are aggrieved by the decision of the Standing Committee of NBWL to approach this Court by filing an appropriate petition/application.
In all those matters where there is already decision of the Standing Committee of the NBWL, shall abide the parties with all the conditions imposed therein.
If any party is aggrieved by the decision of the Standing Committee of the NBWL, they are at liberty to approach an appropriate forum for appropriate relief(s).
With the aforesaid observations and directions, we dispose of the Interlocutory Applications/matters specified in Annexure-II to the note supplied by Shri Harish Salve, learned amicus curiae."

5. Therefore, in view of the references mentioned and explained above, the permission is hereby granted to the The Tata Chemicals Ltd under Section – 29 of Wildlife Protection Act, 1972 for the use of 11.2680 ha land of Block No. 25 in Marine Sanctuary for laying of 2504 m. long and 45 m. wide Waste Water trestle mounted Pipeline subject to following Conditions:

Conditions:

1. The User Agency shall not violate any regulatory provisions under Section - 9, 17 A, 27, 29, 30, 31 & 32 of Wildlife (Protection) Act, 1972.
2. No damage / adverse effect shall be caused to marine life and its habitat by the user agency and its establishment during the implementation of the project. The User Agency or its contractor shall implement the project carefully.
3. User Agency or his contractor shall not use any area of the Sanctuary other than the area permitted for laying of the waste water pipeline and its maintenance.
4. 5% of the cost of the project (Rs. 11.45 Crore) shall be spent for deposited for habitat improvement and wildlife conservation in the Sanctuary area.

5. The User Agency shall discontinue discharge through existing open channels into the marine sanctuary, once proposed pipelines become fully operational.
6. As & when required, the User Agency will obtain permission from the Deputy Conservator of Forests, Marine National Park for maintenance of the waste water pipeline
7. The User Agency will not pollute any of the water channels going to the Marine Sanctuary or Marine National Park in the area.
8. The User Agency is bonded to the precautionary measures suggested for the area on the EIA study carried out.
9. Any other conditions that may be imposed by the Chief Wildlife Warden / Government and or the Standing Committee of the National Board for Wildlife will be strictly complied with.

(G. K. Sinha)
Chief Wildlife Warden
Gujarat State, Gandhinagar.

To,

1. The Chief Conservator of Forests,
   Marine National Park,
   Jamnagar
2. The TATA Chemicals Ltd,
   Mithapur.

Copy Submitted to: The Additional Director General of Forests (WL), Ministry of Environment, Forests and Climate Change, Indira Paryavaran Bhavan, Jor Baug Rad, Ali Ganj, New Delhi for information.

Copy Submitted to: The Additional Chief Secretary, Forest and Environment Department, Sachivalaya, Gandhinagar for information.

Copy to: The Additional Principal Chief Conservator of Forests, Land, Gujarat State Gandhinagar for information and necessary action.

Copy to: The Deputy Conservator of Forests, Marine National Park, Jamnagar for information and necessary action.

3/3

KADAM ENVIRONMENTAL CONSULTANTS

An ISO 9001:2008 Certified Company (MoEF Approved)

871/B/3, Near Himalaya Machinery, GIDC Makarpura, Vadodara-10.
Phone : (O) 0265 - 3001000, 3001001

ENVIRONMENTAL MONITORING REPORT

LABORATORY TEST REPORT - EFFLUENT		
DOC. NO.: LAB-FMT-050	Issue No.: 02	Revision No.: 00
Effective Date:. 01-01-2015	Issue Date: 01-01-2015	Revision Date: 01-01-2015

REPORT NO.: FEB18/093/02

SAMPLE DETAILS

1.	Name & Address of Client: M/s. TATA Chemicals Ltd. Mithapur okhamandal -361 345 Dist. Jamnagar Gujarat.		
2.	Sample ID: 1210898246–093FB18EF01	3.	Client Representative:Mr. Sanjeev Jain
4.	Sample Date: 07.02.2018	5.	Sample Collected By: M/s. TATA Chemicals Ltd.
6.	Analysis commenced on: 12.02.2018	7.	Analysis Completed on: 17.02.2018
8.	Reporting Date: 17.02.2018	9.	Test Requirement: Effluent Analysis
10.	Packing Condition & Quantity: Sealed √	11.	Sample Category: Grab
12.	Sampling Location : **Effluent Sample – 1 Final Discharge**	13.	ETP / STP Status: Working

TEST RESULTS

S.No.	Parameters	Unit (SI)		Results	Specification/ SPCB Norms/BIS Standards	Method Used
1.	pH		:	8.65	6.5-9.5	APHA: (4500-H^+ B) 23rd Edition
2.	Temperature	°C	:	29.1	40	APHA: (2550 B) 23rd Edition
3.	Colour	Pt-CO	:	10	100	APHA: (2120 B) 23rd Edition
4.	Suspended Solids	mg/L	:	327	500	APHA: (2540 D) 23rd Edition
5.	Oil & Grease	mg/L	:	N.D.	2	APHA: (5520 B) 23rd Edition
6.	Ammonical Nitrogen	mg/L	:	1.35	5	IS 3025 (PP 34)
7.	Bio-Assay Test		:	Pass	90 % survival of fish after 96 hrs. in 100% concentration	IS 6582 Part-2, 2001

Remark : N.D.:-Not Detected

Authorised By -

Name : Sapana Amin **Designation : Lab Incharge**

NOTE:
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2) Re analysis of sample will be done, if requested within 15 days from the date of Reporting of sample if the samples are not consumed during analysis.
3) The results reported above relate to the sample identified under Sample Details.

----------END OF REPORT----------

KADAM ENVIRONMENTAL CONSULTANTS

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Phone : (O) 0265 - 3001000, 3001001

ENVIRONMENTAL MONITORING REPORT

LABORATORY TEST REPORT - EFFLUENT		
DOC. NO.: LAB-FMT-050	Issue No.: 02	Revision No.: 00
Effective Date:. 01-01-2015	Issue Date: 01-01-2015	Revision Date: 01-01-2015

REPORT NO.: MAR18/190/02

SAMPLE DETAILS

1.	Name & Address of Client: M/s. TATA Chemicals Ltd. Mithapur okhamandal -361 345 Dist. Jamnagar Gujarat.		
2.	Sample ID: 1210898246-190MR18EF01	3.	Client Representative:Mr. Sanjeev Jain
4.	Sample Date: 06.03.2018	5.	Sample Collected By: M/s. TATA Chemicals Ltd.
6.	Analysis commenced on: 08.03.2018	7.	Analysis Completed on: 13.03.2018
8.	Reporting Date: 03.04.2018	9.	Test Requirement: Effluent Analysis
10.	Packing Condition & Quantity: Sealed √	11.	Sample Category: Grab
12.	Sampling Location : **Effluent Sample – 1 Final Discharge**	13.	ETP / STP Status: Working

TEST RESULTS

S.No.	Parameters	Unit (SI)		Results	Specification/ SPCB Norms/BIS Standards	Method Used
1.	pH		:	8.68	6.5-9.5	APHA: (4500-H^+ B) 23rd Edition
2.	Temperature	°C	:	31	40	APHA: (2550 B) 23rd Edition
3.	Colour	Pt-CO	:	10	100	APHA: (2120 B) 23rd Edition
4.	Suspended Solids	mg/L	:	121	500	APHA: (2540 D) 23rd Edition
5.	Oil & Grease	mg/L	:	N.D.	2	APHA: (5520 B) 23rd Edition
6.	Ammonical Nitrogen	mg/L	:	3.16	5	IS 3025 (PP 34)
7.	Bio-Assay Test		:	Pass	90 % survival of fish after 96 hrs. in 100% concentration	IS 6582 Part-2, 2001

Remark : N.D.:-Not Detected.

Authorised By - ABP

Name : Ashal Patel **Designation : Sr.Chemist**

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----------END OF REPORT----------

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Phone : **(O) 0265 - 3001000, 3001001**

ENVIRONMENTAL MONITORING REPORT

LABORATORY TEST REPORT - EFFLUENT		
DOC. NO.: LAB-FMT-050	Issue No.: 02	Revision No.: 00
Effective Date:. 01-01-2015	Issue Date: 01-01-2015	Revision Date: 01-01-2015

REPORT NO.: APR18/140/02

SAMPLE DETAILS

1.	Name & Address of Client: M/s. TATA Chemicals Ltd. Mithapur okhamandal -361 345 Dist. Jamnagar Gujarat.		
2.	Sample ID: 1210898246–140AP18EF01	3.	Client Representative:Mr. Sanjeev Jain
4.	Sample Date: 04.04.2018	5.	Sample Collected By: M/s. TATA Chemicals Ltd.
6.	Analysis commenced on: 11.04.2018	7.	Analysis Completed on: 16.04.2018
8.	Reporting Date: 24.04.2018	9.	Test Requirement: Effluent Analysis
10.	Packing Condition & Quantity: Sealed √	11.	Sample Category: Grab
12.	Sampling Location : **Effluent Sample – 1 Final Discharge**	13.	ETP / STP Status: Working

TEST RESULTS

S.No.	Parameters	Unit (SI)		Results	Specification/ SPCB Norms/BIS Standards	Method Used
1.	pH		:	8.45	6.5-9.5	APHA: (4500-H^+ B) 23rd Edition
2.	Temperature	°C	:	29.6	40	APHA: (2550 B) 23rd Edition
3.	Colour	Pt-CO	:	8	100	APHA: (2120 B) 23rd Edition
4.	Suspended Solids	mg/L	:	213	500	APHA: (2540 D) 23rd Edition
5.	Oil & Grease	mg/L	:	0.4	2	APHA: (5520 B) 23rd Edition
6.	Ammonical Nitrogen	mg/L	:	3.31	5	IS 3025 (PP 34)
7.	Bio-Assay Test		:	Pass	90 % survival of fish after 96 hrs. in 100% concentration	IS 6582 Part-2, 2001

Remark : N.D.:-Not Detected.

Authorised By - ABP

Name : Ashal Patel **Designation : Sr.Chemist**

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3) The results reported above relate to the sample identified under Sample Details.

----------END OF REPORT----------

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ENVIRONMENTAL MONITORING REPORT

LABORATORY TEST REPORT - EFFLUENT		
DOC. NO.: LAB-FMT-050	Issue No.: 02	Revision No.: 00
Effective Date:. 01-01-2015	Issue Date: 01-01-2015	Revision Date: 01-01-2015

REPORT NO.: MAY18/114/02

SAMPLE DETAILS

1.	Name & Address of Client: M/s. TATA Chemicals Ltd. Mithapur okhamandal -361 345 Dist. Jamnagar Gujarat.		
2.	Sample ID: 1210898246–114MY18EF01	3.	Client Representative:Mr. Sanjeev Jain
4.	Sample Date: 02.05.2018	5.	Sample Collected By: M/s. TATA Chemicals Ltd.
6.	Analysis commenced on: 02.05.2018	7.	Analysis Completed on: 09.05.2018
8.	Reporting Date: 18.05.2018	9.	Test Requirement: Effluent Analysis
10.	Packing Condition & Quantity: Sealed √	11.	Sample Category: Grab
12.	Sampling Location : **Effluent Sample – 1 Final Discharge**	13.	ETP / STP Status: Working

TEST RESULTS

S.No.	Parameters	Unit (SI)		Results	Specification/ SPCB Norms/BIS Standards	Method Used
1.	pH		:	8.81	6.5-9.5	APHA: (4500-H^+ B) 23rd Edition
2.	Temperature	°C	:	34.9	40	APHA: (2550 B) 23rd Edition
3.	Colour	Pt-CO	:	10	100	APHA: (2120 B) 23rd Edition
4.	Suspended Solids	mg/L	:	164	500	APHA: (2540 D) 23rd Edition
5.	Oil & Grease	mg/L	:	N.D	2	APHA: (5520 B) 23rd Edition
6.	Ammonical Nitrogen	mg/L	:	3.80	5	IS 3025 (PP 34)
7.	Bio-Assay Test		:	Pass	90 % survival of fish after 96 hrs. in 100% concentration	IS 6582 Part-2, 2001

Remark : N.D.:-Not Detected.

Authorised By -

Name : Ashal Patel **Designation : Sr.Chemist**

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----------END OF REPORT----------

KADAM ENVIRONMENTAL CONSULTANTS

An ISO 9001:2008 Certified Company (MoEF Approved)

871/B/3, Near Himalaya Machinery, GIDC Makarpura, Vadodara-10.
Phone : **(O) 0265 - 6131000, 6131001**

ENVIRONMENTAL MONITORING REPORT

LABORATORY TEST REPORT - EFFLUENT		
DOC. NO.: LAB-FMT-050	Issue No.: 02	Revision No.: 00
Effective Date:. 01-01-2015	Issue Date: 01-01-2015	Revision Date: 01-01-2015

REPORT NO.: JUN18/103/02

SAMPLE DETAILS

1.	Name & Address of Client: M/s. TATA Chemicals Ltd. Mithapur okhamandal -361 345 Dist. Jamnagar Gujarat.		
2.	Sample ID: 1210898246–103JN18EF01	3.	Client Representative:Mr. Sanjeev Jain
4.	Sample Date: 07.06.2018	5.	Sample Collected By: M/s. TATA Chemicals Ltd.
6.	Analysis commenced on: 15.06.2018	7.	Analysis Completed on: 20.06.2018
8.	Reporting Date: 20.06.2018	9.	Test Requirement: Effluent Analysis
10.	Packing Condition & Quantity: Sealed √	11.	Sample Category: Grab
12.	Sampling Location : **Effluent Sample – 1 Final Discharge**	13.	ETP / STP Status: Working

TEST RESULTS

S.No.	Parameters	Unit (SI)		Results	Specification/ SPCB Norms/BIS Standards	Method Used
1.	pH		:	8.78	6.5-9.5	APHA: (4500-H^+ B) 23rd Edition
2.	Temperature	°C	:	35	40	APHA: (2550 B) 23rd Edition
3.	Colour	Pt-CO	:	10	100	APHA: (2120 B) 23rd Edition
4.	Suspended Solids	mg/L	:	173	500	APHA: (2540 D) 23rd Edition
5.	Oil & Grease	mg/L	:	N.D	2	APHA: (5520 B) 23rd Edition
6.	Ammonical Nitrogen	mg/L	:	2.74	5	IS 3025 (PP 34)
7.	Bio-Assay Test		:	Pass	90 % survival of fish after 96 hrs. in 100% concentration	IS 6582 Part-2, 2001

Remark : N.D.:-Not Detected.

Authorised By -

Name : Sapana Amin **Designation : LabIncharge**

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3) The results reported above relate to the sample identified under Sample Details.

----------END OF REPORT----------

KADAM ENVIRONMENTAL CONSULTANTS

An ISO 9001:2008 Certified Company (MoEF Approved)

871/B/3, Near Himalaya Machinery, GIDC Makarpura, Vadodara-10.
Phone : **(O) 0265 - 6131000, 6131001**

ENVIRONMENTAL MONITORING REPORT

LABORATORY TEST REPORT - EFFLUENT		
DOC. NO.: LAB-FMT-050	Issue No.: 02	Revision No.: 00
Effective Date:. 01-01-2015	Issue Date: 01-01-2015	Revision Date: 01-01-2015

REPORT NO.: JUN18/150/01

SAMPLE DETAILS

1.	Name & Address of Client: M/s. TATA Chemicals Ltd. Mithapur okhamandal -361 345 Dist. Jamnagar Gujarat.		
2.	Sample ID: 1210898246–150JN18EF01	3.	Client Representative:Mr. Sanjeev Jain
4.	Sample Date: 16.06.2018	5.	Sample Collected By: M/s. TATA Chemicals Ltd.
6.	Analysis commenced on: 20.06.2018	7.	Analysis Completed on: 25.06.2018
8.	Reporting Date: 27.06.2018	9.	Test Requirement: Effluent Analysis
10.	Packing Condition & Quantity: Sealed √	11.	Sample Category: Grab
12.	Sampling Location : **Effluent Sample – 1 Final Discharge**	13.	ETP / STP Status: Working

TEST RESULTS

S.No.	Parameters	Unit (SI)		Results	Specification/ SPCB Norms/BIS Standards	Method Used
1.	pH		:	7.89	6.5-9.5	APHA: (4500-H^+ B) 23rd Edition
2.	Temperature	°C	:	30.8	40	APHA: (2550 B) 23rd Edition
3.	Colour	Pt-CO	:	8	100	APHA: (2120 B) 23rd Edition
4.	Suspended Solids	mg/L	:	150	500	APHA: (2540 D) 23rd Edition
5.	Oil & Grease	mg/L	:	N.D	2	APHA: (5520 B) 23rd Edition
6.	Ammonical Nitrogen	mg/L	:	3.07	5	IS 3025 (PP 34)
7.	Bio-Assay Test		:	Pass	90 % survival of fish after 96 hrs. In 100% concentration	IS 6582 Part-2, 2001

Remark : N.D.:-Not Detected.

Authorised By -

Name : Sapana Amin **Designation : Lab Incharge**

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3) The results reported above relate to the sample identified under Sample Details.

----------END OF REPORT----------

KADAM ENVIRONMENTAL CONSULTANTS

An ISO 9001:2008 Certified Company (MoEF Approved)

871/B/3, Near Himalaya Machinery, GIDC Makarpura, Vadodara-10.
Phone : **(O) 0265 - 6131000, 6131001**

ENVIRONMENTAL MONITORING REPORT

LABORATORY TEST REPORT - EFFLUENT		
DOC. NO.: LAB-FMT-050	Issue No.: 02	Revision No.: 00
Effective Date:. 01-01-2015	Issue Date: 01-01-2015	Revision Date: 01-01-2015

REPORT NO.: JUL18/176/02

SAMPLE DETAILS

1.	Name & Address of Client: M/s. TATA Chemicals Ltd. Mithapur okhamandal -361 345 Dist. Jamnagar Gujarat.		
2.	Sample ID: 1210898246–176JL18EF01	3.	Client Representative:Mr. Sanjeev Jain
4.	Sample Date: 11.07.2018	5.	Sample Collected By: M/s. TATA Chemicals Ltd.
6.	Analysis commenced on: 16.07.2018	7.	Analysis Completed on: 20.07.2018
8.	Reporting Date: 20.07.2018	9.	Test Requirement: Effluent Analysis
10.	Packing Condition & Quantity: Sealed √	11.	Sample Category: Grab
12.	Sampling Location : **Effluent Sample – 1 Final Discharge**	13.	ETP / STP Status: Working

TEST RESULTS

S.No.	Parameters	Unit (SI)		Results	Specification/ SPCB Norms/BIS Standards	Method Used
1.	pH		:	8.08	6.5-9.5	APHA: (4500-H^+ B) 23rd Edition
2.	Temperature	°C	:	31.1	40	APHA: (2550 B) 23rd Edition
3.	Colour	Pt-CO	:	10	100	APHA: (2120 B) 23rd Edition
4.	Suspended Solids	mg/L	:	196	500	APHA: (2540 D) 23rd Edition
5.	Oil & Grease	mg/L	:	N.D	2	APHA: (5520.B) 23rd Edition
6.	Ammonical Nitrogen	mg/L	:	3.57	5	IS 3025 (PP 34)
7.	Bio-Assay Test		:	Pass	90 % survival of fish after 96 hrs. in 100% concentration	IS 6582 Part-2, 2001

Remark : N.D.:-Not Detected.

Authorised By -

Name : Sapana Amin **Designation : Lab Incharge**

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----------END OF REPORT----------