BEFORE THE NATIONAL GREEN TRIBUNAL

WESTERN BENCH, PUNE

ORIGINAL APPLICATION NO. 73 of 2021

IN THE MATTER OF:

BRACKISH WATER RESEARCH CENTRE & ANR. …….APPLICANT (S)

VERSUS

MOEFCC & ORS. ……RESPONDENTS (S)

INDEX

Place: Nagpur, Maharashtra

Dated: 08/01/2026

Filed By: Advocate for Respondent No. 1

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IN THE MATTER OF:

BRACKISH WATER RESEARCH

CENTRE & ANR. .....APPLICANT (S)

VERSUS

MOEFCC & ORS. .....RESPONDENTS (S)

REPLY AFFIDAVIT ON BEHALF OF RESPONDENT NO.1 I.E., MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE

I, E.Thirunavukkarasu S/o M. Elangovan, aged about 58 years, presently working as Scientist 'F' at the Ministry of Environment, Forest & Climate Change (MoEF&CC), Regional Office, Ground Floor, East Wing, New Secretariat Building, Civil Lines, Nagpur, do hereby solemnly affirm and state as under:-

Mrs. S. R. MATTA NOTARY NAGPUR DIST. (M.S) INDIA Reg. No.6776 My Term Expires on 21/ GOVT. OF INDIA

1. That I am, the above-named Deponent, authorized and well conversant with the facts and circumstances of the present case and thus competent to swear the present Affidavit.

2. That, the MoEF&CC is filing an affidavit at this stage and it craves leave and liberty to file any further affidavit to the aforesaid application, as and when required.

3. It is respectfully submitted that the Hon'ble National Green Tribunal ('NGT') vide order dated 02.12.2021 had constituted a 6-member Joint Committee, wherein MoEFCC was directed to be the nodal agency and directed the Committee to look into the details of the problem of pollution due to "Tar Ball" and other petroleum materials as mentioned in this original application and suggest technical and administrative mechanism to address them effectively. The Hon'ble NGT vide order dated 17.04.2023 also directed the Joint Committee to look into the fact whether corpus fund can be created for that purpose and submit its report on this aspect.

4. It is humbly submitted that the Hon'ble NGT vide order dated 09.09.2025 had directed respondent no.1 to place on record the documents/reports before the Hon'ble NGT before finalization of the Rules. That, in compliance with the directions and observations of this Hon'ble NGT, the MoEFCC is filing the present report detailing

the action taken in the captioned matter. A copy of the Action Taken Report is annexed herewith and marked as **Annexure-I**.

5. It is respectfully submitted that in view of the above submissions, this Hon'ble Tribunal may pass such order(s) as deemed fit and proper in the facts and circumstances of the case.

DEPONENT

(ई. थिरुनावुक्करसु)
(E. Thirunavukkarasu)
वैज्ञानिक 'एफ' / Scientist 'F'
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
Min. of Environment, Forest and Climate Change
क्षे.कार्यालय, नागपूर-४४०००१
Regional Office, Nagpur-440001

VERIFICATION

Verified at Nagpur on this 8th day of January, 2026 that the contents of this affidavit based on official record(s) maintained and information available in the office are true and correct, no part of it is false and nothing has been concealed there from.

DEPONENT

(ई. थिरुनावुक्करसु)
(E. Thirunavukkarasu)
वैज्ञानिक 'एफ' / Scientist 'F'
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
Min. of Environment, Forest and Climate Change
क्षे.कार्यालय, नागपूर-४४०००१
Regional Office, Nagpur-440001

NOTARIAL REG. No. 827 DATE 8/1/2026

NOTARY MRS. S. R MATTA DIST. NAGPUR (M.S.) REGD. NO. 6776 GOVT. OF INDIA

Mrs. S. R. MATTA NOTARY NAGPUR DIST. (M.S) INDIA Reg. No. 6776 My Term Expires on 21/9/2028 GOVT. OF INDIA

SWORN BEFORE ME ON THIS 8th DAY OF Jan 2026 AT NAGPUR BY SHRI / SMT/KU. E. Thirunavukkarasu R/O NAGPUR WHO HAS BEEN IDENTIFIED BY SHR / SMT..... ADVOCATE, NAGPUR.

Mrs. S. R. MATTA
ADVOCATE & NOTARY
18-B, Clarke Town, Nagpur-1

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ANNEXURE-I

ACTION TAKEN REPORT IN COMPLIANCE OF THE ORDER OF HON'BLE NGT IN O.A. NO. 73 OF 2021- BRACKISH WATER RESEARCH CENTRE VS. MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE & ORS

I. BACKGROUND

1. The matter relates to the formation of tar balls along the west coast of India (in the States of Gujarat, Maharashtra and Goa) during monsoon season. The Hon'ble NGT is hearing upon the matter in OA No. 73/2021 (Brackish Water Research Centre vs. GPCB & Others). The matter was first listed on 27.10.2021 and notice was issued to the respondents, returnable on 02.12.2021. On 02.12.2021, the Hon'ble Tribunal had directed for formation of 6-member Joint Committee comprising of the following:

i) GOI-MoEFCC represented by Secretary;

ii) GOI-MoPNG represented by Secretary;

iii) CPCB represented by Member Secretary; &

iv) Secretaries of Environment and Forest Dept. of State of Maharashtra, State of Gujarat and State of Goa.

*[Copy of Order dated 02.12.2021 passed by Hon'ble NGT, WZ, in OA no. 73/2021 is annexed herein as **Reference 1**.]*

2. MoEFCCwas directed to be the nodal agency. The Committee was directed to suggest a meaningful solution to arrest and abate the "Tar Ball" problem etc.; to look into the details of the pollution due to Tar Ball and other petroleum materials and suggest technical and administrative mechanism to address them effectively.

II. ACTION BY MOEFCC

Constitution of Joint Committee

3. In compliance of Hon'ble NGT order, MoEFCC vide order dated 21.03.2022 has constituted a Joint committee with the following members:

1. Secretary, Ministry of Environment, Forest & Climate Change (MoEFCC)
2. Secretary, Ministry of Petroleum and Natural Gas (MoPNG)
3. Secretary, Environment and Forest Departments, Govt. of Maharashtra
4. Secretary, Environment and Forest Departments, Govt. of Gujarat
5. Secretary, Environment and Forest Departments, Govt. of Goa
6. Member Secretary, Central Pollution Control Board

*[Copy of Constitution order of Joint Committee 22.03.2022 is annexed herein as **Reference 2.**]*

The Term of Reference of the Committee is given below:

i. *Look into the details of the problem of pollution due to "Tar Ball" and other petroleum materials.*
ii. *Suggest solutions to arrest and abate the "Tar Ball" problem.*
iii. *Suggest technical and administrative mechanisms to address the problem*
iv. *Suggest requirement and make recommendation with regard to the requirement of a corpus fund for undertaking shore cleaning up activities in the affected states (As directed by the Hon'ble NGT vide order dated 17.04.2023).*

Ministry of Ports, Shipping and Waterways and National Institute of Oceanography were also invited as 'Special Invitees to the Committee'.

Constitution of Technical Sub-Committee

4. The 1st meeting of the Joint Committee was held on 12.04.2022 under the Chairmanship of Secretary, MoEFCC*[Copy of Records of discussion of 1st meeting of Joint Committee is annexed herein as **Reference 3**.]* wherein it was decided that considering that the handling of the subject requires specific domain expertise, a Technical sub-Committee is constituted to assist the NGT constituted Committee. The major decisions and deliberations of the NGT Constituted Committee were as under:

Being a highly technical matter requiring domain expertise,the CPCB will act as the nodal agency for convening the business of 'Technical sub-Committee', with MoEFCC support. *[Copy of Constitution order of Technical Sub-Committee 05.05.2022 is annexed herein as **Reference 4**.]*

The 'Terms of Reference of the 'Technical sub-Committee' would be as follows:

i. *Identification of the source of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.*
ii. *Review the current mechanism of addressing tar-ball problem at Indian coasts/ beaches and identify gaps, if any*
iii. *Suggest preventive measures required at source to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls, covering global best practices*
iv. *Suggest mechanisms to arrest tar-balls at Sea, based on global practices*
v. *Suggest administrative and technical frameworks as well as monitoring/ vigil mechanisms that can be introduced under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies*
vi. *Prepare Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger Ships/ Cargo*

Vessels, Oil Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOS-DCP)

The 1st meeting of the Technical Sub-Committee was held on 10.05.2022. The major decisions and deliberations of the Committee are as under:

The Technical sub-Committee agreed upon the following issues:

a) There is no method available to track, quantify and control crude oil seepage and slicks of natural origin.
b) Tar ball formations resulting from anthropogenic sources can occur due to offshore oil exploration activities, oil tanker accidents, oil-well blowouts, pipeline leakages, release of bilge and industrial effluent from ships and tanker washes/ leakage spills along tanker route.
c) Considering the busy international shipping route along the west coast, it is very difficult to attribute a single source for tar ball formations with high degree of confidence
d) The tar-ball problem formation is a global issue and many countries are grappling with the problem due to location of oil fields, international shipping routes etc.
e) In view of the uncertainty associated with tar ball source identification, it would be an appropriate strategy to prepare scenario-specific Standard Operating Procedures for stakeholders

The Technical Sub-Committee decidedthat a study needs to be conducted with CSIR-NIO as lead agency and CPCB and MoPNG as co-lead. The other key stakeholders like Indian Coast Guard, which has already formulated a National Oil-Spill Disaster Contingency Plan (NOS-DCP), was also requested to provide technical and administrative support to the study.

The broad ToR of the study was as follows:

i. Identification of various sources of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.

ii. Review the current mechanism of addressing tar-ball problem at Indian coasts/ beaches and identification of gaps

iii. Suggest preventive measures required at source in respect of all scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc. to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls

iv. Study of global best practices on prevention of tar balls formation and measures taken to contain tar ball pollution

v. Suggest viable mechanisms to arrest tar-balls at Sea, based on global practices

vi. Suggest introducing administrative and technical frameworks for monitoring/ under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies

vii. Prepare detailed Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger Ships/ Cargo Vessels, Oil Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOSDCP).

*[Copy of Records of discussion of 1st meeting of Technical Sub-Committee is annexed herein as **Reference 5**.]*

Award of Study to CSIR-NIO, CPCB and MoPNG

6. MoEFCC awarded a project to CSIR-NIO, CPCB, MoPNG to study the aspects related to tar ball formation and its management vide sanction order dated 01.12.2022. MoPSW/DG Shipping, Indian Coast Guard, Gujarat Pollution Control Board were also the participating agencies. Thereafter, in the intervening period, the MoEFCC asked CSIR-NIO to cover the issue of requirement of a corpus fund for undertaking shore cleaning up activities in the affected states (as directed by the Hon'ble NGT vide order dated 17.04.2023)

7. The CSIR-NIO vide letter dated 29.09.2023 submitted the Project Report on Formation of Tarballs along the Gujarat, Maharashtra and Goa Coasts: Constraints on possible sources and mitigation measures. The report on the issue of 'requirement of a corpus fund for undertaking shore cleaning activities in the affected States' recommended that appropriate departments that can raise the corpus funds are the MoPNG and MoPSW. *[Copy of CSIR-NIO report on Formation of Tar-balls along the Gujarat, Maharashtra and Goa Coasts: Constraints on possible sources and mitigation measures is annexed herein as **Reference 6**.]*

8. The 2nd meeting of Technical Sub-Committee was held on 07.11.2023 *[Copy of Records of discussion of 2nd meeting of Technical Sub-Committee is annexed herein as **Reference 7**.]*

9. Thereafter, the 2nd meeting of the Joint Committee constituted by the Hon'ble NGT, was conducted on 17.01.2024 under the co-chairship of Secretary, MoEFCC and Secretary. MOPNG *[Copy of Records of discussion of 2nd meeting of Joint Committee is annexed herein as **Reference 8**.]*. The major deliberations of the committee were on the following issues:

- The origin of tar-balls or source identification be further worked upon to remove any kind of doubt or ambiguity on the source of tar-balls as the area under reference i.e. west coast of India, is an international

shipping route as well as an oil-rich area wherein many oilfields and commercial exploration activities are operational.

- The International Oil Pollution Compensation Fund (IOPC) is already operational under the auspices of the International Maritime Organization (IMO) to provide financial compensation for oil pollution damage that occurs in Member States, resulting from spills of persistent oil from tankers.
- Commercial offshore oil exploration operations are industrial processes, and their routine compliance monitoring vis-a-vis applicable environmental regulations needs to be analysed.
- Need for identification and fixation of the physical scope of the problem, i.e. the extent of the coastal area impacted by the tar-ball formations.

10. Based on the deliberations, the Committee decided that TSC may take up the following issues through further study by the engagement of all relevant stakeholders:

a. To find the source of tar-balls by through acceptable scientific source apportionment tools available.
b. To explore the utilization of the IOPC fund as a financing mechanism for management of tar-balls, for which India makes substantial contribution.
c. To assess the environmental compliance of offshore oil exploration operations in general, and oil spill management in particular, through involvement of ICG, MoPNG, PCBs, Maritime Boards and CZMAs of Goa, Gujarat and Maharashtra.
d. To assess leakages/ spills by shipping lines in the west coast and fix their responsibility in formation of tar balls.
e. To identify and fix the physical extent of the affected area along western coast, covering details of districts, population, commercial and livelihood activities impacted, and enlist typical remedial

measures based on which the actual requirement of districts for remedial measures and quantum of corpus fund can be worked out.

III. FORMULATION OF RULES

11. The Technical Sub-Committee was re-constituted vide order dated 24th April, 2024 by MoEF&CC *[Copy of Re-Constitution order of Technical Sub-Committee 24.04.2024 is annexed herein as **Reference 9**.]*. The 3rd meeting of Technical Sub-Committee was held on 04.09.2024 wherein the committee was of the view that it is difficult to exactly pinpoint the source of Tar Ball formation and there is a need for taking collaborative preventive and corrective measure to address this issue. *[Copy of Records of discussion of 3rd meeting of Technical Sub-Committee is annexed herein as **Reference 10**.]*

12. The Technical Sub-Committee in its 3rd meeting recommended that a rule may be notified by the MoEF&CC under Environment (Protection) Act, 1986 to address the issues of Tar Balls and the broad contours of the said notification and other action required for the same may be as follows:

a. CPCB shall prepare the draft rules in consultation with other stakeholders
b. The rules shall provide for preventive and mitigative measures and responsibilities of various stakeholders.
c. The rules shall provide for creation of a fund and contribution to it by relevant stakeholders on no fault basis. The mitigation measures will be financed for the above fund.
d. The rules shall provide the implementing, monitoring, auditing and reporting mechanism.
e. The rules shall have a steering committee comprises of representatives from Ministry of Environment, Forest and Climate Change (MoEF&CC), Ministry of Petroleum and Natural Gas

(MoPNG), Ministry of Ports, Shipping, and Waterways (MoPSW), and other stakeholders.

f. The above committee will monitor the implementation of these rules and also expenditure from the above mentioned fund.

13. The CPCB submitted the draft rules and the same were placed before Technical-Sub Committee for its consideration in the 4th meeting of TSC held on 04.04.2025, which recommended that the draft rules be improved upon based on the discussion and the modified draft rules be presented before the Joint Committee. *[Copy of Records of discussion of 4th meeting of Technical Sub-Committee is annexed herein as **Reference 11**.]*

14. The modified draft was shared by the CPCB and after review, it was decided that the MoEFCC would revise the draft rules and circulate them to the relevant Ministries/Departments for comments. The revised version of the draft rules, including a para on creation and management of Corpus Fund at MoPSW, was circulated to the concerned stakeholders including MoPSW, MoPNG, MoES, Indian Coast Guard, CPCB and State Governments. The inputs received from the stakeholders were examined in the Ministry and necessary provisions were duly incorporated into the revised Draft Rules.

15. The revised draft Tar Balls Management Rules after incorporating the relevant comments were again circulated with all the stakeholders including MoPSW, MoPNG, MOES, Indian Coast Guard, CPCB and State Governments. The 5th Meeting of Technical Sub-Committee, was then convened on 16.09.2025 to discuss the revised draft rules, including the para on creation and management of Corpus Fund at MoPSW, in detail. Based on the discussion it was decided that minor changes suggested in the draft rules be incorporated and the modified draft rules be presented before Joint Committee constituted by NGT as report/recommendation of the TSC. *[Copy of Records of discussion of 5th meeting of Technical Sub-Committee is annexed herein as **Reference 12**.]*

16. The 3rd meeting of Joint Committee was convened on 25.11.2025 wherein after detailed deliberations, the committee suggested that for the Corpus Fund, additional options and agencies be explored as potential contributors. *[Copy of Records of discussion of 3rd meeting of Joint Committee is annexed herein as **Reference 13**.]*

17. To address the suggestion made by the Joint Committee a meeting was conducted on 23.12.2025 under the chairmanship of Addl. Secretary, MoEFCC to discuss the provision of Corpus Fund under the draft Tar ball Management rules. In the said meeting, inputs/comments were sought from MoPSW. However, MoPSW sought additional time to furnish comments, in discussion with DG, Shipping. Subsequently, an OM dated 23.12.2025 was issued by MoEFCC to MoPSW. *[Copy of Records of discussion of meeting held on 23.12.2025 is annexed herein as **Reference 14**.]*

18. MoPSW conducted a meeting on 31.12.2025 under the chairmanship of Special Secretary, MoPSW on the issue of Corpus Fund. MoPSW suggested that, if a corpus fund is considered necessary, it may be more appropriately placed with MoEF&CC or MoP&NG or alternatively referred to in the rules in a generic manner, without naming a specific Ministry. *[Copy of Minutes of Meeting held on 31.12.2025 is annexed herein as **Reference 15**.]*

19. In light of the above, a meeting of Joint Committee is being proposed to be convened to deliberate on the issue of Corpus fund.

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Item No. 14 (Pune Bench)

BEFORE THE NATIONAL GREEN TRIBUNAL
WESTERN ZONE BENCH, PUNE

(By Video Conferencing)

Original Application No.73/2021 (WZ)

Brackish Water Research Centre Applicant(s)

Versus

Gujarat Pollution Control Board & Ors. Respondent(s)

Date of hearing: 02.12.2021

CORAM: HON'BLE MR. JUSTICE M. SATHYANARAYANAN, JUDICIAL MEMBER
HON'BLE DR. ARUN KUMAR VERMA, EXPERT MEMBER

Applicant: Ms. Shilpa Chohan, Advocate
Respondent: Mr. Rahul Garg, Advocate for R-1& 5
Mr. Maulik Nanavati, Advocate for R 4& 6
Mr. Rohan Talwar, Advocate for R-07
Mr. Vilas Jadhav, Advocate for R-10
Ms. Anuya S. Kulkarni, Advocate for R-14
Mr. Chirag Dave, Advocate for R-17
Mr. Pavithran A.V. Advocate for R-18 & 19

ORDER

1. The matter in issue pertains to spillage of crude oil or a heavier refined product float on the ocean surface and the Tribunal in continuation of the earlier order dated 27.10.2021, is passed the following order:-

(i) Heard the submissions of Ms. Shilpa Chohan, Learned Counsel appearing for the Original Applicant, Mr. Rahul Garg, Learned Counsel appearing for Respondent No. 1 and 5, Mr. Maulik Nanavati, Learned Counsel appearing for the Respondent Nos. 4 and 6, Mr. Rohan Talwar, Learned Counsel appearing for Respondent No.7, Mr. Vilas Jadhav, Learned Counsel appearing for Respondent No.10, Ms. Anuya S. Kulkarni, Learned Counsel appearing for Respondent No.14, Mr. Chirag Dave, Learned Counsel appearing for Respondent No.17

and Mr. Pavithran, Learned Counsel appearing for Respondent No.18 and 19.

(ii) Mr. Maulik Nanavati, Learned Standing Counsel appearing for Respondent Nos. 4 and 6 would submit that since the stakeholders are also Central Government entities, the Tribunal may form an appropriate committee, consisting of majority of the stakeholders so that a meaningful exercise can be taken out to arrest the problem as pointed out by the Applicant in the present Original Application.

(iii) The respective Learned Counsels who have accepted notices, pray for time to file their reply affidavits with supporting documents.

(iv) The issue arises for consideration in this Original Application, requires thorough and detail consideration and in light of the contents of the Original Application with supporting documents. The Tribunal is of the considered view that a Joint Committee is to be constituted consisting of the following Members:-

1. Government of India-Ministry of Environment Forests & Climate Change (MoEF&CC) represented by the Secretary;
2. Government of India-Ministry of Petroleum and Natural Gas, represented by the Secretary;
3. Central Pollution Control Board represented by the Member Secretary;
4. Secretaries of Environment and Forest Departments of State of Maharashtra, State of Gujarat and State of Goa.

(v) The Ministry of Environment Forests & Climate Change represented by the Secretary, Govt. of India, is the nodal agency.

(vi) It is open to the Committee to seek the assistance of any specified agency/agencies to suggest a meaningful solution to arrest and abate the

"Tar Ball" problem etc., and if any clarification/direction is required, the Nodal Agency namely MoEF &CC also entitled to file memo/s before the Tribunal for seeking appropriate directions.

(vii) The Committee should look into the details of the problem of pollution due to "Tar Ball" and other petroleum materials as mentioned in this original application and suggest technical and administrative mechanism to address them effectively.

(viii) The Learned Counsel appearing for the Original Applicant undertakes to serve the copies of the Original Application as well as supporting documents upon the respective Learned Counsels who have entered appearance on behalf of the Official Respondents.

(ix) Though, the Respondent No.3 has been served and their name appears in the cause list, there is no representation on their behalf.

(x) Communicate the copy of all the orders passed in this Original Application to the official Respondents and also by way of email and upload the copy of this order on the website.

(xi) Call on 02.02.2022.

M. Sathyanarayanan, JM

Dr. Arun Kumar Verma, EM

December 02, 2021
Original Application No.73/2021 (WZ)

JG

HSM-11/22/2022-HSM
Government of India
Ministry of Environment, Forest and Climate Change
(HSM Division)

1st Floor, Jal Wing
Indira Paryavaran Bhawan
Jorbagh Road, New Delhi

Date: 21st March, 2022

Office Order

Sub: Constitution of Committee in pursuance of the directions of Hon'ble NGT order dated 02.12.2021 in the matter of O.A. No. 73 of 2021 (Brackish Water Research Center Vs Gujarat Pollution Control Board & Ors) relating to coastal and marine pollution due to tar balls - reg.

In pursuance of the directions of the Hon'ble NGT (Western Zone Bench) dated 02nd December, 2021, a Joint Committee is hereby constituted to look into the matters related to marine and coastal pollution due to the floating oil and tar balls in sea waters.

2. The Joint Committee shall comprise of the following:

S. No.	Committee Members	Description
1.	Secretary, Ministry of Environment, Forest & Climate Change (MoEFCC), Govt. of India	Convenor
2.	Secretary, Ministry of Petroleum and Natural Gas (MoPNG), Govt. of India	Member
3.	Secretary, Environment and Forest Departments, Govt. of Maharashtra	Member
4.	Secretary, Environment and Forest Departments, Govt. of Gujarat	Member
5.	Secretary, Environment and Forest Departments, Govt. of Goa	Member
6.	Member Secretary, Central Pollution Control Board (CPCB)	Member

3. The 'Terms of Reference' for the above-mentioned Joint Committee shall be as under:

i. Look into the details of the problem of pollution due to "Tar Ball" and other petroleum materials
ii. Suggest solutions to arrest and abate the "Tar Ball" problem
iii. Suggest technical and administrative mechanism to address the problem

4. The Ministry of Environment, Forest and Climate Change shall coordinate the activities related to work of the Joint Committee. The Committee may co-opt or seek assistance of other stakeholders as deemed necessary to facilitate the assigned task.

5. This issues with the approval of Secretary (EF&CC).

(Ved Prakash Mishra)
Director (HSMD)

To:

All Members (As per the list)

Copy for information to:

PS to MEFCC/ PPS to Secretary (EF&CC)/PS to AS (HSMD)/SO (HSMD)/ Guard file / Website

List of Members:

Sl. No.	Member	Contact details	
		Landline No./ Mobile No.	Email
1.	Secretary, MoEF&CC	011- 20819308	Secy-moef@nic.in
2.	Secretary, MoPNG	011- 23383562	Sec.png@nic.in
3.	Member Secretary, CPCB	011- 22303655	Mscb.cpcb@nic.in
4.	a) Principal Secretary, Environment, State of Maharashtra b) Principal Secretary, Forest Departments, State of Maharashtra	022- 22873845 022- 22023363	Psec.env@maharashtra.gov.in Sec.forest@maharashtra.gov.in
5.	Additional Chief Secretary, Environment and Forest Departments, State of Gujarat	079-23251051	secfed@gujarat.gov.in
6.	Director, Environment and Forest Departments, State of Goa	0832- 2416581	dir-env.gov@nic.in

'Records of Discussion' of the 1st meeting of the Committee constituted by Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to formation of Tar-balls along the coast of Goa, Gujarat and Maharashtra

A meeting of the Committee constituted by Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to formation of Tar-balls near the coast/ beaches of Goa, Gujarat and Maharashtra was held on 12-April-2022. The meeting was steered by Ms. Leena Nandan, Secretary, MoEFCC. The meeting participants included other Committee members *viz.* Additional Secretary, MoPNG (as representative of Secretary, MoPNG), Member Secretary-CPCB and Secretary In-charge of State Environment Departments of Gujarat and Maharashtra. Considering the subject under reference and its linkage to other agencies, special invitees from National Institute of Oceanography, Indian Coast Guard (M/o Defence) and National Institute of Ocean Technology (under Ministry of Earth Sciences) attended the meeting. The Committee Member *viz.* Secretary In-charge of State Environment Departments of Goa and special invitee from Ministry of Shipping did not attend the meeting.

2. At the outset, the Additional Secretary, MoEFCC welcomed all the participants and provided a background of the issue. The meeting participants were informed that the issue under reference is related to tar-balls pollution. The Hon'ble NGT has taken cognizance of the matter on the petition filed by two NGOs. Based on the issued raised by petitioners, the Hon'ble NGT has directed for constitution of a committee comprising Secretary, MoEFCC; Secretary, MoPNG; Member Secretary, CPCB and the State Secretary In-charge of Environment and Forests of Goa, Gujarat and Maharashtra. In compliance to the order, MoEFCC had issued an order for creation of the committee with the 'Terms of Reference' given by the Hon'ble Tribunal. This is the first (1st) meeting of the Committee to discuss the issue and decide upon the course of action considering that the subject is highly technical and requires requisite domain expertise. Thereafter, MoPNG wss requested to make its presentation.

3. Director General of Hydrocarbons and the Director (Offshore), ONGC jointly delivered the MoPNG presentation. The presentation covered an introduction on tar-balls problem, mechanism of its formation, typical sources of tar-balls formation, characteristics of tar-balls, adverse impacts of tar-balls on various aspects (*viz.* marine environment, aesthetic environment, human health, social & financial issues, inter-government conflicts in responding to tar-balls occurrence. The presentation also covered previous incidents of tar-balls occurrences and typical steps to manage the tar-balls problem. The MoPNG has mentioned that typical tar-balls sources are ship washing wastewater, ballast water, old sunken ships, natural seepage from offshore oil-fields, leakages from Oil and gas platforms/ rigs and industrial/ municipal wastewater discharge.

4. The MS-CPCB submitted that due to complexity of the problem the issues need to be dealt in a phased manner. It was suggested that the typical approach to be followed in this matter might comprise of root cause analysis for source identification, study to assess the impact potential of tar-balls formations, cleaning up on coast/ beaches & disposal of tar waste *(in case of occurrence at shore)* and preparation of standard response protocols for all stakeholders.

5. The representative from National Institute of Oceanography submitted that as per the research studies done by the institute, including fingerprint analysis, the source of tar-balls is Bombay-High (BH) fields. The NIO studies *(biomarker diagnostic ratios and homophone index)* have reportedly mapped the characteristics of tar balls with the crude oil from various offshore fields and found similarities with Bombay-High crude. However, it is mentioned that the presence may be due to some unidentified leakage or seepage from BH fields like drilling wells.

6. The State In-charges of Environment Department of Gujarat and Maharashtra shared their experiences on handling of tar balls problem and mentioned that the clean-up and disposal of tar-balls from coastal areas is done by ULB and State PCBs. The disposal of tar balls is done by incineration through TSDFs operational in the state. It was also mentioned that the tar balls occurrences are monsoon specific events.

7. The Chair summed up the deliberations and highlighted that the handling of the subject requires specific domain expertise and accordingly, it would be appropriate to constitute a Technical sub-Committee to assist the NGT constituted Committee. Further, since the matter relates to multiple agencies having specific roles in abatement of marine pollution, oil spill response, marine environment research, addressing pollution related aspects of tar-balls, employing marine environment research techniques and drawing references from existing studies, it is proposed that the 'Technical Sub-Committee' may comprise of the following:

- Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC – Chairman
- Shri Amarnath, Additional Secretary, MoPNG - Co-chair
- Member Secretary, Central Pollution Control Board
  Dr. Suneel Vasimalla, Senior Scientist, National Institute of Oceanography
- Shri Ved Prakash Mishra, Director (HSMD), MoEFCC - Member Convenor
  Shri R. K. Kureel, Director, MoPNG
- Director-level representative, Ministry of Ports, Shipping and Waterways
- Director-level representative, Indian Coast Guard (M/o Defence)
- Dr. Prince Prakash Jeba Kumar J, Scientist, National Institute of Ocean Technology, Ministry of Earth Sciences
- Representatives of Environment & Forest Departments of Goa, Maharashtra and Gujarat

8. The Chair requested all the participants to nominate their representatives to the ‘Technical sub-Committee’, at the earliest, so that the work in hand can be initiated. Being a highly technical matter requiring domain expertise, the CPCB will act as the nodal agency for convening the business of ‘Technical sub-Committee’, with MoEFCC support. The ‘Terms of Reference of the ‘Technical sub-Committee’ would be as follows:

- Identification of the source of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.
- Review the current mechanism of addressing tar-ball problem at Indian coasts/ beaches and identify gaps, if any
- Suggest preventive measures required at source to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls, covering global best practices
- Suggest mechanisms to arrest tar-balls at Sea, based on global practices
- Suggest administrative and technical frameworks as well as monitoring/ vigil mechanisms that can be introduced under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies
- Prepare Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger Ships/ Cargo Vessels, Oil Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOS-DCP)

The meeting ended with vote of thanks to and from the Chair.

*****

List of Participants

1. Ms. Leena Nandan, Secretary, MoEFCC – In Chair
2. Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC
3. Shri Amar Nath, Additional Secretary, MoPNG
4. Shri Praveen Raghav, Director General, Hydrocarbons
5. Dr. A. P. Singh, Addl. Chief Secretary, Forest and Environment Department, Govt. of Gujarat
6. Ms. Manisha Patankar Mhaiskar, Principal Secretary, Environment Department, Govt. of Maharashtra
7. Dr. Prashant Gargava, Member Secretary, CPCB
8. Dy. Director General, Indian Coast Guard, Ministry of Defence
9. Shri Pankaj Kumar, Director (Offshore), ONGC
10. Dr. Suneel Vasimalla, National Institute of Oceanography
11. Shri Ved Prakash Mishra, Director, MoEFCC
12. Shri R. K. Kureel, Director, MoPNG
13. Dr Prince Prakash Jeba Kumar, National Institute of Ocean Technology, Ministry of Earth Sciences
14. Shri Dinesh Runiwal, Scientist-E, MoEFCC

HSM-11/22/2022-HSM
Government of India
Ministry of Environment, Forest and Climate Change
(HSM Division)

1st Floor, Jal Wing
Indira Paryavaran Bhawan
Jor Bagh Road, New Delhi

Date: 5th May, 2022

Office Order

Sub: Hon'ble NGT matter O.A. No. 73 of 2021 titled as Brackish Water Research Centre Vs Ministry of Environment, Forest & Climate Change & Ors relating to coastal and marine pollution due to tar balls- Constitution of Technical Sub-Committee - reg.

In pursuance of the directions of the Hon'ble NGT (Western Zone Bench) dated 02nd December, 2021, the Government of India, Ministry of Environment, Forest and Climate Change had issued a committee constitution order on 21.03.2022 to look into the matters related to marine and coastal pollution due to the floating oil and tar balls in sea waters. The Committee met under the chairmanship of Secretary, MoEFCC on 12.04.2022. The Committee noted during the deliberations that considering the complexity of the tar balls problem and technical (research-oriented) experience required for finding solutions, it would be appropriate to constitute a 'Technical sub-Committee' to assist the NGT constituted Committee.

2. Apropos above, the undersigned is directed to inform that considering the research domain expertise required for the work in hand, a Technical Sub-Committee with following members is hereby constituted:

Committee Member	Description
Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC	Chairman
Shri Amarnath, Additional Secretary, MoPNG	Co-chair
Member Secretary, Central Pollution Control Board	Member
Dr. Suneel Vasimalla, Sr. Scientist, National Institute of Oceanography	Member
Shri R. K. Kureel, Director, MoPNG	Member
Director-level representative, Ministry of Ports, Shipping and Waterways	Member
Commandant Asheesh Sharma, Indian Coast Guard (M/o Defence)	Member
Dr. Prince Prakash Jeba Kumar J, Scientist, National Institute of Ocean Technology, Ministry of Earth Sciences	Member
Representatives of Environment & Forest Departments of Goa, Maharashtra and Gujarat	Member
Shri Ved Prakash Mishra, Director (HSMD), MoEFCC	Member Convener

3. The 'Terms of Reference' for the above-mentioned technical sub-committee would be as under:

i. Identification of the source of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.
ii. Review the current mechanism of addressing tar-ball problem at Indian coasts/ beaches and identify gaps, if any
iii. Suggest preventive measures required at source to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls, covering global best practices
iv. Suggest mechanisms to arrest tar-balls at Sea, based on global practices
v. Suggest administrative and technical frameworks as well as monitoring/ vigil mechanisms that can be introduced under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies
vi. Prepare Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger Ships/ Cargo Vessels, Oil Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOS-DCP)

4 Considering the complexity of subject and technical know-how and expertise required, the CPCB shall undertaking the technical activities with support of other stakeholders which include preparation of report, SOPs, technical and administrative frameworks, study on global practices, review existing mechanism etc. The MoEFCC shall provide support to CPCB by undertaking administrative coordination with stakeholders, information flow among agencies, convening of Meetings and MoM preparation.

5. This issues with the approval of Secretary (EF&CC).

(Ved Prakash Mishra)
Director

To:

All Members (As per the list)

Copy for information to:

PS to MEFCC/ PPS to Secretary (EF&CC)/ PPS to AS (RSP)/ PS to JS (HSMD)/ IFD/ GC/ Budget Division/SO (HSMD)/ Guard file / Website

List of Members:

S.No.	Committee Member	Contact details
1	Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC	asnpg.mef@nic.in
2	Shri Amarnath, Additional Secretary, MoPNG	amar.nath94@nic.in
3	Member Secretary, Central Pollution Control Board	mscb.cpcb@nic.in
4	Dr. Suneel Vasimalla, Senior Scientist, National Institute of Oceanography	suneel@nio.org
5	Shri R. K. Kureel, Director, MoPNG	rk.kureel@nic.in
6	Director-level representative, Ministry of Ports, Shipping and Waterways	secyship@nic.in
7	Commandant Asheesh Sharma, Coast Guard Headquarters (M/o Defence)	dte-fe@indiancoastguard.nic.in
8	Dr. Prince Prakash Jeba Kumar J, Scientist, National Institute of Ocean Technology, Ministry of Earth Sciences	prince@niot.res.in
9	Representatives of Environment & Forest Departments of Goa, Maharashtra and Gujarat	Psec.env@maharashtra.gov.in Sec.forest@maharashtra.gov.in secfed@gujarat.gov.in Dir-env.gov@nic.in
10	Shri Ved Prakash Mishra, Director (HSMD), MoEFCC	mishra.vp@gov.in

'Records of Discussion' of the 1st meeting of the Technical Sub-Committee created to assist the Hon'ble NGT Committee constituted in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to formation of Tar-balls along the coast of Goa, Gujarat and Maharashtra

A meeting of the Technical Sub-Committee created to assist the Hon'ble NGT committee in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to formation of Tar-balls near the coast/ beaches of Goa, Gujarat and Maharashtra was held on 10-May-2022. The meeting was chaired by Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC. The meeting participants included other Technical Sub-Committee members *viz.* representatives from M/o Ports, Shipping and Waterways; M/o Petroleum and Natural Gas, CPCB, Indian Coast Guard, CSIR-NIO, NIOT-M/o Earth Sciences and State representatives from Goa, Gujarat and Maharashtra.

2. At the outset, the Director (HSMD), MoEFCC welcomed all the participants and provided a background of the issue. The meeting participants were informed that in compliance to the order of Hon'ble NGT, MoEFCC had issued an order for creation of the committee with the 'Terms of Reference' given by the Hon'ble Tribunal. The NGT Committee met on 12-April-2022 to discuss the issue and decide upon the course of action considering that the subject is highly technical and requires requisite domain expertise. Accordingly, it was decided to create a Technical Sub-Committee to support and assist the NGT Committee. The MoEFCC had issued a 'Technical Sub-Committee' constitution order dated 05th May, 2022. In the same reference, this meeting is organized to discuss the modalities to initiate further work.

3. Thereafter, the CRIS-NIO representative was requested for making a brief presentation on the R&D work undertaken by NIO so far on the issue. The NIO representative gave a brief overview of the formation of tar balls in the sea through weathering action and indicated that winds and currents cause the spilled/ seeped oil to spread followed by its dispersion due to wave action and turbulence at sea surface, ultimately breaking the oil slick into fragments and droplets. These fragments/ droplets sink to bottom for sedimentation and mixes with water, soil/ sand particles to form emulsion, which further weathers and breaks into pieces and forms tar balls. Various instances of tar ball formations were shown to the sub-Committee. It was informed that NIO has undertaken various studies like chemical fingerprinting using biomarker analysis, Lagrangian particle tracking, Remote sensing of oil spills

and trajectory simulation to assess the typical source of tar ball formations.

4. The NIO study attributed various reasons for tar ball formation like offshore oil exploration activities, oil tanker accidents, oil-well blowouts, pipeline leakages, release of bilge and industrial effluent from from ships and tanker washes/ leakage spills along tanker route. Out of the various studies done by NIO, it was noted that some of the studies have tried to closely relate the probable source of tar balls. However, it was also noted by the Committee that the west coast is among the busiest shipping routes and it is almost impossible to find out exact source. Apart from the above, there could be high chances of natural seepage from oil field which may be beyond the control of offshore field operators.

5. The CPCB representative also made a presentation highlighting the environmental concerns of Tar Ball formation like adverse impact on aquatic life and livelihood of coastal communities; adverse health impact due to consumption of contaminated seafood; soil contamination; loss of resources/ energy due to leakage/ slicks; disturbance to coastal marine habitats; exposure of flora, fauna and humans to tar balls on the beaches and adverse impact on tourism and other economic activities of coastal habitats. The CPCB also shared the action taken by it previously on tar ball issue in association with GPCB, MPCB, NIO, ICG and ONGC. The CPCB representative highlighted that the following aspects need to be considered by the Technical sub-Committee:

- Root cause analysis for source identification
- Acceptance of finger print analysis results of tar balls by stakeholders
- Study to assess the impact potential of tar-balls formations and impact on marine environment including ecology
- Procedure for cleaning up of coast/ beaches & disposal of tar ball waste
- Preparation of standard response protocols for all stakeholders with well defined roles and responsibility
- Predictive modelling for travel path of Tar balls
- Integrated study of tidal movements through modelling, satellite images and ground-truthing in addition to aerial surveillance for a longer period
- Extensive survey of off-shore oil platforms and group gathering stations with respect to handling and spillage of oil.

6. The Technical sub-Committee, thereafter, undertook detailed discussion in the matter and the following issues were agreed upon:

- There is no method available to track, quantify and control crude oil seepage and slicks of natural origin.

- Tar ball formations resulting from anthropogenic sources can occur due to offshore oil exploration activities, oil tanker accidents, oil-well blowouts, pipeline leakages, release of bilge and industrial effluent from from ships and tanker washes/ leakage spills along tanker route.
- Considering the busy international shipping route along the west coast, it is very difficult to attribute a single source for tar ball formations with high degree of confidence
- The tar-ball problem formation is a global issue and many countries are grappling with the problem due to location of oil fields, international shipping routes etc.
- In view of the uncertainty associated with tar ball source identification, it would be an approprite strategy to prepare scenario-specific Standard Operating Procedures for stakeholders

7. In light of the above, the Technical Sub-Commitee decided that a study needs to be conducted with CSIR-NIO as lead agency and CPCB and MoPNG as co-lead. The other key stakeholders like Indian Coast Guard, which has already formulated a National Oil-Spill Disaster Contingency Plan (NOS-DCP), was also requested to provide technical and administrative support to the study. The broad ToR of the study shall be as follows:

- Identification of various sources of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.
- Review the current mechanism of addressing tar-ball problem at Indian coasts/ beaches and identification of gaps
- Suggest preventive measures required at source in respect of all scenarios like
  operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc. to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls
- Study of global best practices on prevention of tar balls formation and measures taken to contain tar ball pollution
- Suggest viable mechanisms to arrest tar-balls at Sea, based on global practices
- Suggest introducing administrative and technical frameworks for monitoring/ under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies
- Prepare detailed Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger Ships/ Cargo Vessels, Oil

Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOSDCP)

8. Apropos above, the CSIR-NIO, CPCB and MoPNG were requested to prepare and submit a formal Project document to undertake a study in line with the deliberations made above. The project study document may cover with detailed 'Terms of reference' in alignment with the aspects already highlighted in para 7 above.

The meeting ended with vote of thanks to and from the Chair.

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List of Participants

1. Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC
2. Shri Amar Nath, Additional Secretary, MoPNG
3. Shri Ved Prakash Mishra, Director, MoEFCC
4. Shri R. K. Kureel, Director, MoPNG
5. Shri Dinabandhu Gouda, CPCB
6. Shri Asheesh Sharma, Indian Coast Guard, Ministry of Defence
7. Dr. Suneel Vasimalla, National Institute of Oceanography
8. Dr Prince Prakash Jeba Kumar, National Institute of Ocean Technology, Ministry of Earth Sciences
9. Shri Dinesh Runiwal, Scientist-E, MoEFCC
10. Representative of Maharashtra PCB
11. Representative of Gujarat PCB

Reference 6

स्वर्ण जयंती वर्ष
सी एस आई आर - राष्ट्रीय समुद्र विज्ञान संस्थान
(वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद)
दोना पावला, गोवा 403 004 भारत
CSIR - National Institute of Oceanography
(Council of Scientific & Industrial Research)
DONA PAULA, GOA - 403 004, India
75 Years of CSIR Touching Lives

Date: 29.09.2023

To

The Director
HSM Division (2402)
Ministry of Environment, Forest and Climate Change
Indira Paryavaran Bhavan, New Delhi -110003

Sub: Project report submission regarding

Dear Sir,

In response to the revised OM issued by the MoEF&CC, HSM Division, dated 04.08.2023 (File No. 11/22/2022 (part)-HSMD, a project study on " Formation of Tarballs along the Gujarat, Maharashtra and Goa Coasts: Constraints on possible sources and mitigation measures" is jointly carried out by CSIR-NIO, CPCB, MoPNG/ONGC with MoPSW/DG Shipping, ICG, GSPCB are as participating agencies. The completed project report is attached herewith.

Thank you for your consideration and cooperation

Yours sincerely

(Dr.Suneel Vasimalla)

CSIR-NIO

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A PROJECT REPORT ON

Formation of Tarballs along the Gujarat, Maharashtra and Goa Coasts: Constraints on possible sources and mitigation measures

Conducted by

CSIR-National Institute of Oceanography

Ministry of Petroleum and Natural Gas

Central Pollution Control Board

Participating Agencies

Ministry of Ports, Shipping and Waterways

Indian Coast Guard

Submitted to

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

September 2023

CSIR-NATIONAL INSTITUTE OF OCEANOGRAPHY
(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)
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Introduction

The spillage of oil and petroleum products into the sea occurs from various natural and anthropogenic sources, which includes offshore oil exploration, tanker accidents, oil-well blow-outs, accidental and deliberate release of the bilge, discharges of municipal sewage, industrial effluents, pipeline rupture, and operational leakages at the oil fields, SPMs (Single point Moorings), and spillage along the tanker-route. The tarball is a weathered product of oil spills; usually develops through various physical, chemical, and biological processes.

After any spillage of oil in marine environments, mostly lighter fractions of the oil evaporate while the remaining oil mixes with water and forms water-in-oil emulsions. These emulsions on the sea surface undergo several physical, biological, and chemical processes (Chandru et al., 2008, Jordan and Payne, 1980). Those weathering processes include spreading, evaporation, dissolution, biodegradation, emulsification, sedimentation, dispersion, and oxidation, which leave emulsified oil components that are denser and viscous in nature (NAS, 2003). This emulsion may contain 70–80% water and forms a glue-like mass, commonly known as 'chocolate mousse' (Clark, 2002). After a long period, those floating emulsified masses will disintegrate into smaller lumps and eventually get transported to various places, including coastal beaches following ocean currents. Subsequently, the lumps of oil residue; stranded on beaches, are commonly referred to as 'tarballs' (Chandru et al., 2008). Those stranded oil residues or tarballs generally appear spherical in shape and very dark in colour. Those lumps of weathered oil remain in a semisolid or solid state and are usually sticky. Various sources of petroleum in the marine environment; particularly, tanker washing and routine shipping operations contribute significantly to tarball genesis (Clark, 2002). Petroleum exploration activities in marine environments could have caused spills, which also eventually led to the formation of tarballs (Chandru et al., 2008).

Tarballs are dark-colored substances that accumulate in sizes ranging from small globules to those as big as a basketball. Tarballs, tar mats, and tar patties are typical forms of marine tar residues and which have a size range from millimeters in diameter (tarballs) to several meters in length or width (tar mats); as well as can vary considerably in colour, shape, size, chemical makeup, and aroma (Warnock et al., 2015). The term tarball is used to describe a discrete, roughly spherical accumulation of weathered oil generally less than 10cm in diameter. Discrete tar aggregates larger than 10cm in diameter are referred to as tar patties. Significant, thick accumulations of oil residues that are partially or completely submerged in water are referred to as tar mats (Warnock et al., 2015). According to their densities, the prevailing temperature, and the degree of weathering, tarballs are observed as floating, sinking, or being washed onto the beaches in the marine environment. Thus marine tars can be categorized as pelagic or benthic-types. Pelagic tars are usually found to float on the surface or in submerged conditions below the surface, while benthic tar residues reside on the seafloor. Sometimes, the weathered emulsion breaks into pieces and thus forms pelagic tarballs or patties. With time, pelagic tar balls may settle on seafloor; after being subjected to processes that increase their specific gravity (Balkas, 1982).

The oil residue in marine environments might produce intense ecological damage; however, impacts caused by such petroleum residue cannot be quantified easily. In most cases, they may lead to significant economic and irreversible environmental losses. Several studies indicated that onshore accumulation of such tarballs might pose deleterious impacts on benthic organisms (Del Sontro et al., 2007; Warnock et al., 2015). In the marine environment leaching of toxic compounds from tarballs may cause toxic hydrocarbon contaminations in seawater. Polycyclic Aromatic Hydrocarbons (PAHs) are one of the most toxic hydrocarbons available in these petroleum products, among which the low molecular weight components are more water-soluble and readily bioavailable for aquatic animals; however, the high molecular weight

PAHs are more toxic and carcinogenic. Thus, contamination of food sources may also have lethal effects on many other species of different trophic levels. Moreover, exposure to toxic oil compounds also affects the immune systems of various animals (Barron et al. 2012). The accumulation of tarball on shore may cause severe environmental risks for coastal regions as the water, sediment quality, biodiversity, and many other ecological factors can be significantly affected. Therefore, to avoid such a considerable threat to the marine environment, it is essential to identify the tarball sources and mitigate their environmental consequences.

Since the 1970s, several records showed tarball deposition in many parts of the Indian west coast is a very common observation during the southwest monsoon (April to September) (Dwivedi et al., 1974, Dhargalkar et al., 1977, Suneel et al. 2013, 2014, 2015). The tarball depositions along the south Gujarat coast, particularly on the beaches of Umbhrat, Onjal, Bhagal, Navsari, Nargol, and Umargam, during the first week of August 2018 and July 2019 (Fig. 1) have received significant attention from various stakeholders including Environmentalists, Gujarat Pollution Control Board (GPCB), Central Pollution Control Board (CPCB), Indian Coast Guard, Ministry of Environment, Forest and Climate Change (MoEF&CC), and Ministry of Petroleum and Natural Gas (MoPNG). Similar tarball depositions are also evident along the Goa coast more or less every year. The Goa State Pollution Control Board (GSPCB), the Government of Goa are also concerned on the issue. Several meetings and discussions have been conducted among the above-mentioned departments on that issue.

The outcome of those meetings, as recommended by the majority of the stakeholders, is that an investigation on tarball must be undertaken to address the several questions and ambiguities of such deposits. In that context, the CSIR-National Institute of Oceanography was

requested to carry out the study as a leading agency, with CPCB, MoPNG, MoPSW, and Indian Coast Guard as participating agencies.

Figure 1. Illustration of tarball depositions on the beaches of south Gujarat during July 2019. (a). Onjal, (b) Nargol, (c) Bhagal, (d) Umargam beaches.

In light of the above background, and the intervention of Honorable NGT, the present study has been proposed to understand various possible sources of oil spills, which lead to the formation of tarballs all along the Gujarat, Maharashtra, and Goa coasts. Based on the results of this study, the suggestions for possible mitigation measures and the standard operating procedures concerning the different identified oil spill sources would be formulated, aligning with the National Oil Spill Disaster Contingency Plans (NOS-DCPs).

Participating Agencies

- CSIR-National Institute of Oceanography (CSIR-NIO)
- Central Pollution Control Board (CPCB)
- Ministry of Petroleum and Natural Gas (MoPNG)/ Oil and Natural Gas Corporation (ONGC)/IPSHEM, Betul, Goa
- Ministry of Ports, Shipping and Waterways (MoPSW)/ DG Shipping
- Indian Coast Guard (ICG)

Objectives

1. Identification of various sources of tarballs covering all possible scenarios like the operation of offshore oil fields, ship leakages/discharges, oil spill events, etc.

2. Review the current mechanism of addressing the tarball problem at India Coasts/beaches and identify gaps.

3. Suggest preventive measures required at source in respect of all scenarios, like the operation of offshore oil fields, ship leakages/discharges, oil spill events, etc., to minimize leakage of oil/petroleum materials and eventually lead to the formation of tarballs.

4. Study of global practices on prevention of tarball formation and measures taken to contain tarball pollution. Suggest viable mechanisms to arrest tarball at sea based on global practices.

5. Suggest introducing administrative and technical frameworks for monitoring under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies.

6. Prepare detailed Standard Operating Procedures (SOPs) in alignment with the NOSDCP for typical tarball sources like Offshore oil field operators, Passenger Ships/Cargo vessels, and Oil spill events.

7. Suggest requirements and make recommendations with regard to the requirement of a corpus fund for undertaking shore cleaning activities in the affected states.

Objective 1: Identification of various sources of tarballs covering all possible scenarios like the operation of offshore oil fields, ship leakages/discharges, oil spill events, etc.

Incidents of tarball deposition along the west coast of India (WCI) have been observed since the 1970s, and several Indian researchers (Nair et al., 1972; Dwivedi and Parulekar, 1974; Qasim, 1975; Dhargalkar et al., 1977; Oostdam, 1984; Kadam, 1988; Sengupta et al., 1993; Kadam and Rokade, 1996; Kaladharan et al., 2004) studied the chemical properties of tarballs with analytical facilities available at that time. We recently observed that the rate of tarball deposition along the WCI varies from year to year; and in certain years, it becomes very significant. The deposition of tarballs on the beaches is proportional to the volume of oil spilled in the sea from different sources. The primary sources of oil spills in the sea are offshore oil exploration, oil tanker accidents, oil-well blow-outs, and accidental and deliberate release of bilge from ships. Besides that, the waste discharges through river run-off, municipal sewage and industrial effluents are also expected to contribute the oil pollution; although these may not lead to tarball formation. Natural seepage of crude oil from the seafloor is another prominent source of oil pollution in the marine environment. According to the source of oil spills, various preventive measures/plans should be followed to avoid any deleterious impacts on the marine environment.

i. ***Offshore oil explorations:*** Every offshore oil exploration system that has a risk of producing marine oil or chemical pollution is required to maintain a facility contingency plan approved as per National Oil Spill Disaster Contingency Plan (NOS-DCP).

ii. ***Natural seepage of crude oil:*** Natural seepage of oil is not an anthropogenic activity and may require a different approach like monitoring through satellite datasets. Therefore, it is not covered in NOS-DCP.

iii. ***Merchant ships:*** Every ship is required to follow the MARPOL regulations to maintain oil pollution prevention equipment on board, Shipboard Marine Pollution Emergency Plan (SOPEP) approved by the Flag State Administration. The Merchant Shipping (Prevention of Pollution by Oil) Rules, 2010 has introduced operational and constructional prevention measures, prevention of oil discharges, and maintenance of a pollution emergency plan by Indian ships approved by the Administration or Recognized Organisation acting on its behalf. The rules specify the limits of the prohibited zones, the equipment to be carried on board the ship and general precautions to be taken for the prevention of leakage and accidental discharges as well as precautions to be taken while loading, transferring, and unloading oil by tankers. The rules also require all vessels to maintain an oil records book to indicate any operations carried out on board with respect to the oil. In a nutshell, NOS-DCP covers all aspects related to the prevention of oil spills and effective response mechanisms in case of oil spills with detailed guidelines/procedures to deal with such incidences.

Immediately after any incidence of an oil spill in the sea, it undergoes the influence of various physical, chemical and biological processes, which together are called weathering processes. In Fig. 2, the variety of the weathering processes of an oil spill in a marine environment has been presented. In most cases, such weathering processes cause fast dispersion of approximately half of the spilled oil from the source within 24 hrs, particularly in warm tropical regions. After 24 hrs, depending on the sea state, water-in-oil emulsion (mousse) may be formed (Sengupta et al., 1993). In case of strong wind, the suspended matter in seawater might get adsorb onto the oil-water emulsion surface. Winds, waves, and turbulence at the sea surface cause the emulsion to break into smaller pieces, which eventually develop as tarballs.

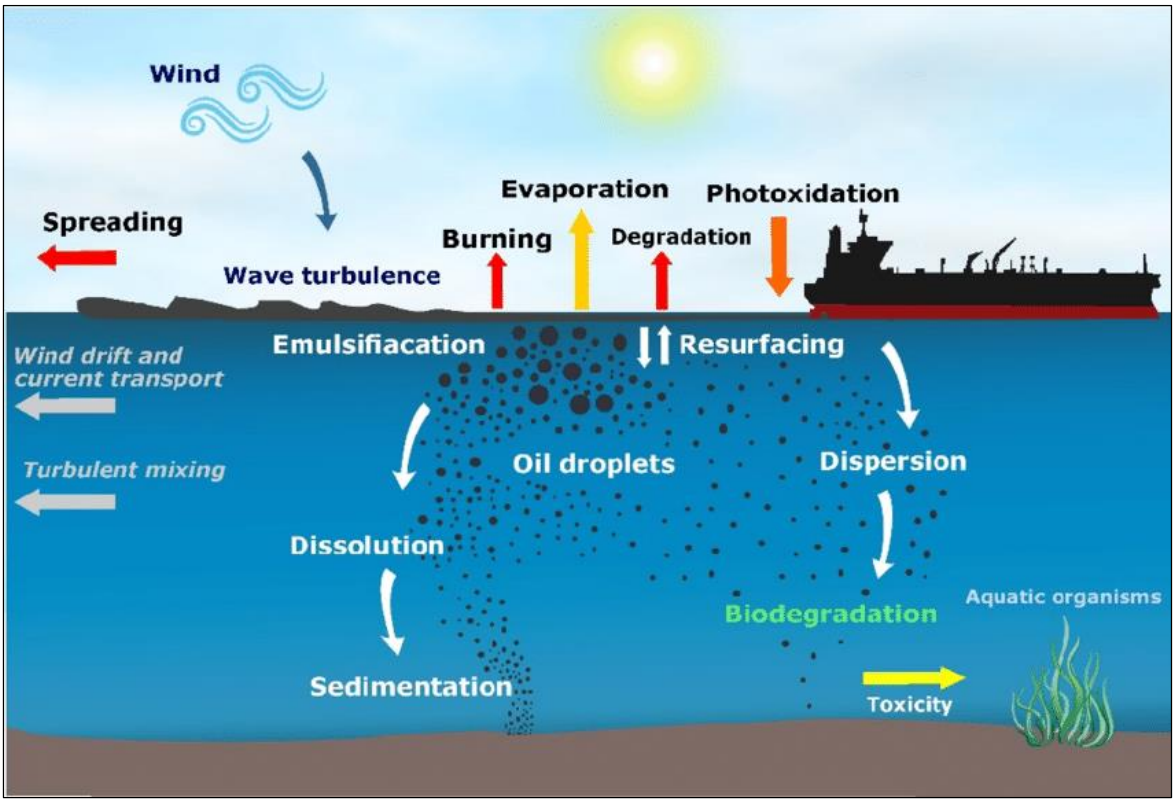

Figure 2. Schematic picture displaying various processes involved in weathering of the oil spill in the marine environment.

Identification of the actual source(s) of crude oil in any natural tarball deposit is a challenging task; however, the "Fingerprinting technique" based on certain biomarker studies can produce very useful information regarding the source of any oil pollution. To date, several studies have been carried out on this aspect; to find the source of tarball/oil spills all over the world. For such investigation; particular biomarkers in the oil spill, which are highly resistant to weathering are widely used for such fingerprinting and environmental forensic studies (Wang et al. 1994b, Wang et al. 1995b, Zakaria et al. 2000, Zakaria et al. 2001, Chandru et al. 2008, Suneel et al. 2013a). Generally, the natural crude oils formed during different geological time scales unveils unique biomarker fingerprint. Thus, the chemical analysis of biomarkers plays a prominent role in fingerprinting studies of tarballs.

The diagnostic ratios (DRs) of biomarkers like Pentacyclictriterpanes (Hopanes) and Steranes are often estimated for oil/tarball fingerprinting studies. The Hopane DRs C_{29}/C_{30} and $\sum C_{31}$-C_{35}/C_{30} are more reliable source identifiers for oil spill fingerprinting (Zakaria et al., 2000, 2001). However, the most used include tricyclic C_{23}/C_{24}, C_{29} αβ/ C_{30} αβ hopane, Oleanane/C_{30}αβ hopane, homo-hopane distribution, Ts/Tm, Ts/(Ts+Tm), triplet ratio (C_{24} tetra cyclic terpane/C_{26} tricyclic(S)/C_{26} tricyclic (R), regular sterane distribution (C_{27}-C_{28}-C_{29} ααα and αββ (20S+20R), C_{26}-C_{27}-C_{28} triaromaticsteranes (TA) and C_{27}-C_{28}-C_{29} monoaromatic steranes (MA) distribution (Wang et al., 2004). Mulabagal et al. (2013) fingerprinted the tar balls that are deposited on the Alabama shoreline using the DRs of hopane and sterane compounds such as Ts/Tm, C_{29}αβ/C_{30}αβ, C_{31}(22S)/C_{31}(22S+22R), C_{32}(22S)/C_{32}(22S+22R), C_{33}(22S)/C_{33}(22S+22R), C_{34}(22S)/C_{34}(22S+22R), & C_{35}(22S)/C_{35}(22S+22R). They estimated weathering levels of tarball samples based on the concentration of C_{30}, 50% of C_{30} remains even after two years. They further experimented on the rate of evaporation of crude oil by evaporating a known quantity of oil and measuring the weight of the sample periodically. Their result showed crude oil can evaporate by ~25% within a day, 30% within 2 days, 40% within a month, and about 47% in 6 months.

1.1 Fingerprinting studies for delineating the source(s) of tarballs deposited along the Goa and Gujarat coasts of the west coast of India – A few case studies

1.1.1 Fingerprint of the source of tarballs deposited along the Goa coast using the multi-disciplinary analysis

During August 2010, most of the Goa beaches were affected by tarball deposition. The deposition was very significant and attracted the attention of the public, media, and other stakeholders. The scientific experts from CSIR-National Institute of Oceanography, Goa also visited all the affected beaches and collected the samples. Following that, Suneel et al. (2013a) conducted a fingerprint study in an attempt to identify the source of oil in those tarballs for the

first time in India. The sampling procedure, sample extraction procedure, and the sample analysis through Gas Chromatography and Mass Spectrometer (GCMS) and GC-Isotope Ratio Mass Spectrometer (GC-IRMS) are explained in details in Annexure - A. This study has used the diagnostic ratio (DR) of alkanes, triterpenes (Hopane Biomarkers), and the compound-specific isotope analysis (CSIA) of the tarballs and thus compared with the oil source from the Bombay High (BH) region. The results were also compared with the available databases of Middle East Crude Oils (MECO) and South East Asian Crude Oils (SEACO).

This comparative study indicated that the source oil does not match the BH oil sample, but closely matches with the SEACO. But then a question was raised regarding the transportation of SEACO oil residues to the Goa coast. For such incidents, the most possible source could be the unknown spillages along the international tanker lines. To address all these issues, another case study was conducted by Suneel et al. (2013b); in which the hydrodynamic model coupled with the particle tracking model in the sea was used. In this study (Suneel et al. 2013b), the tarball transport is tracked by using the Particle Analysis (PA) module of MIKE 21. PA module is based on the Lagrangian Random walk technique and is used for the simulation of the trajectory of tarballs which are considered as floating passive particles. The winds and currents data for the period of August 2010 have been used as input parameters to run this PA module. For this, the currents are obtained from the MIKE 21HD (Hydrodynamic) and winds from the Weather research and Forecasting (WRF) model. Tarball trajectories were determined by the random release of particles weighing 5gm at probable locations (one particle at each location) in the Arabian Sea (Fig. 3a) on 02 August 2010. Particles released at the locations Au1 (70.320 E, 16.290 N), Au2 (70.410 E, 16.200 N), Au3 (70.595 E, 16.010 N) Au4 (70.690 E, 15.920 N) and Au6 (69.500 E, 15.800 N) only reached the Goa coast as shown in Fig. 3d.

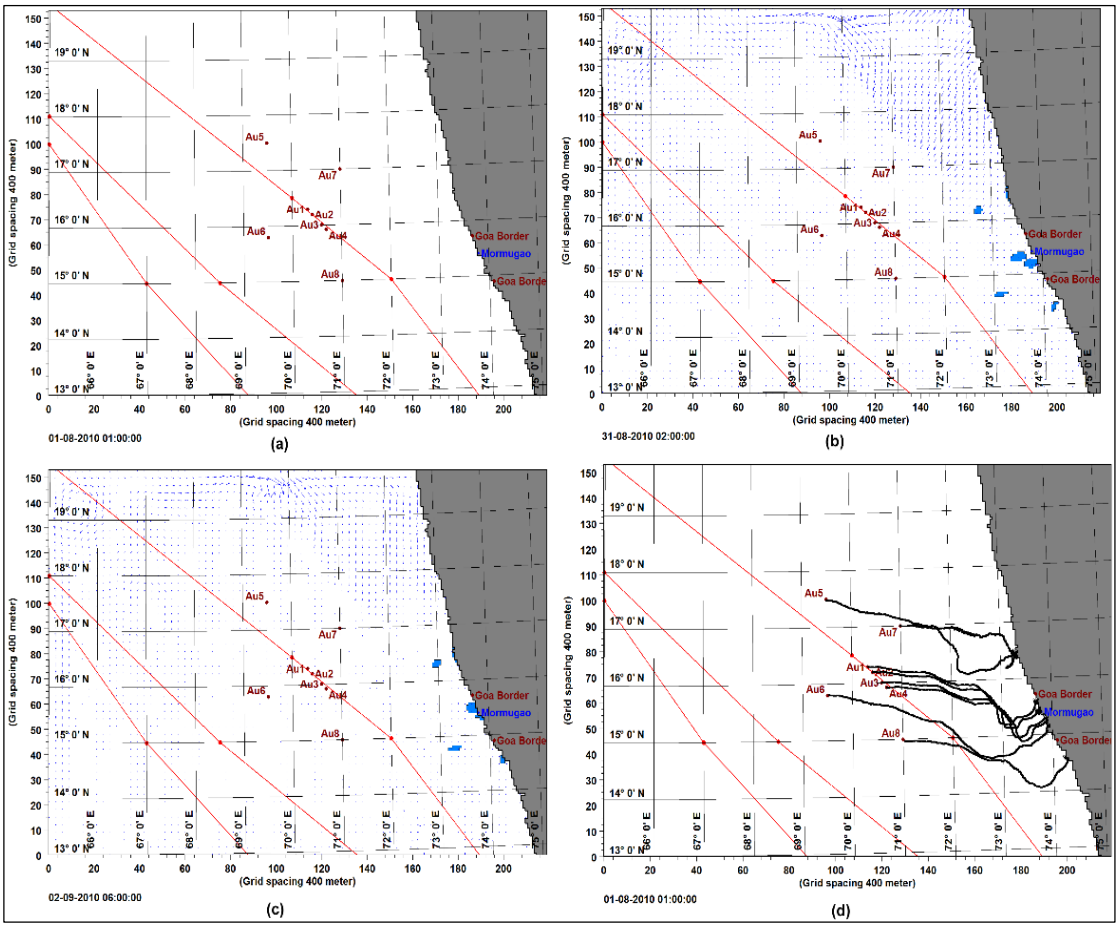

Figure 3. Snapshots of the simulated tarball trajectories deposited along the beaches of Goa in August 2010 (Source: Suneel et al. 2013b).

It is interesting to note that the particles released at other points Au5 (69.50 E, 15.80 N), Au7 (71 0E, 17 0N) and Au8 (71 0E, 15 0N) did not reach the Goa coast (Fig. 3d), and reached elsewhere at further north and south of Goa coast. Among the eight particles which moved out from their initial release point, three particles (Au3, Au4 and Au6) reached the south Goa coast as shown in Fig. 3b and the other two particles (Au1 and Au2) reached the north Goa coast as shown in Fig 3c. These transport patterns were in close agreement with the observation.

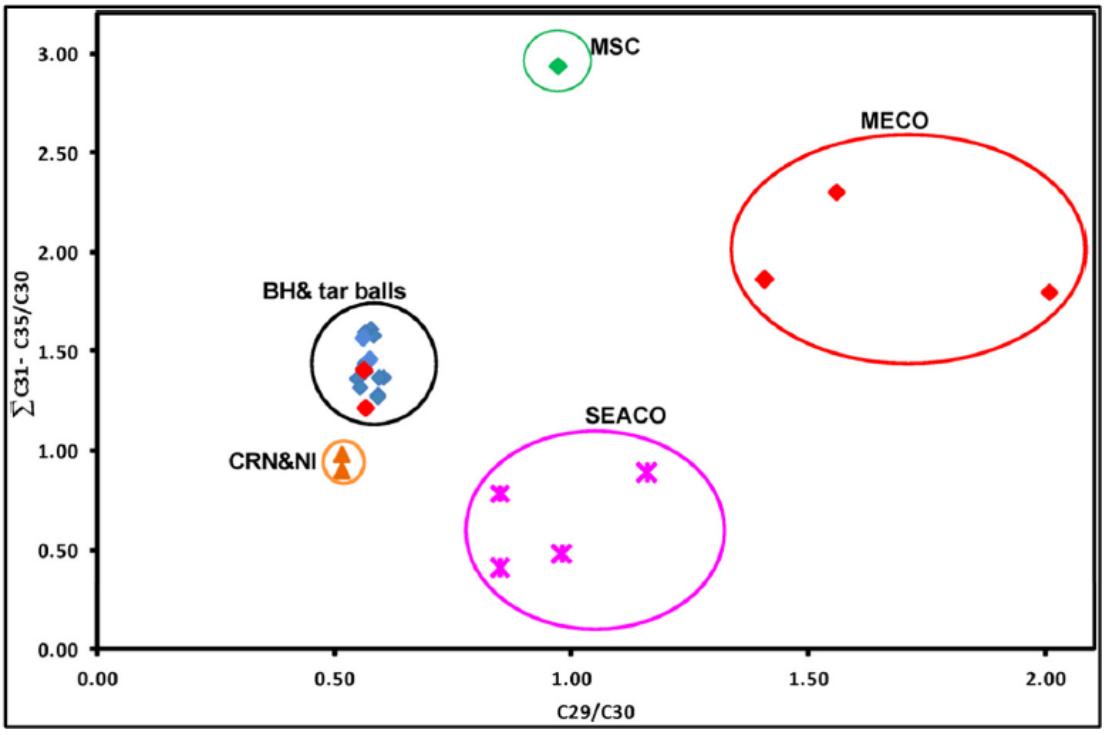

Figure 4. Bi-plot between the ratios C_{29}/C_{30} vs ΣC_{31}–C_{35}/C_{30} for tar balls and various crude oils. The red and blue diamonds in the black circle are BH crude oils (BHM_{oil} & BHH_{oil}) and tar balls respectively showing the match between tarballs and BH crude oils. The other colours represent various other crude oils such as Southeast Asian Crude Oils (SEACO), Middle East Crude Oils (MECO), Cairn and Niko crude oils (CRN & NI), MSC Chitra crude oils (MSC)

It may be noted that tar balls initially arrived along the south Goa beaches on 30 August 2010 (Anonymous, 2010), and subsequently moved to north Goa beaches. The authors have not compared the actual tarball transport time (from initial movement to deposition) with the model-simulated time, as they do not know the actual transport time. They further added that the properties (size, mass, volume) of released particles and the actual tarball properties may differ considerably. The model-simulated trajectories match very well with the circulation pattern of the AS. The trajectories of the particles in Fig. 3d are toward the southeast direction (clockwise direction). Thus, they concluded that wind-driven circulation during the southwest monsoon season together with tides transported the tarballs toward the Goa coast during August 2010, and the tanker-derived oil spills along the International oil tanker route might be the

source of these tarballs. These results complement Suneel et al. (2013a) where the source of those tarballs closely matches the SEACO oil. Likewise, Suneel et al. (2015) have also conducted a multi-marker fingerprinting such as DRs of n-alkanes, cross-plots of pentacyclic terpenes (hopanes), regular sterane compounds, CSIA and Principal Component Analysis (PCA) for fingerprinting the source of the tarballs deposited along the Goa coast during May 2013. Their results indicated that the source of the 2013 tar balls should have originated from the Bombay High oil fields (Fig. 4). The authors further stated that the causes for the BH crude oil spill are not known; however, the possibility of leakage in the pipelines, natural seepage, or multiple causes as sources for this May 2013 deposit cannot be ruled out and they recommended long-term monitoring.

1.1.2 Backtrack modelling of the tarball deposited along the beaches of Goa during 2013 and 2014 – a case study.

In another study, Suneel et al. (2016) observed that tarball depositions during 2013 and 2014 landed on the Goa coast almost during the same period (i.e., 27–28 May 2013 and 26–28 May 2014). They have used the backtracking model to identify the origins of both these deposits. The methods used for the study are explained in detail in Annexure - A. The particles were seeded numerically for the same period (27 to 28 May 2013 and 26 to 28 May 2014) and they noticed the real tarball depositions and backtracked for 45 and 75 days, respectively. In general, strong monsoonal wind prevails in the Arabian Sea during the month of May and changes its direction significantly in August. The particle trajectories of May 2013 and May 2014 are northwestward (towards BH oil fields) from the seeded location, and reached the oil fields in about 30 and 65 days for the years 2013 and 2014 respectively (Fig. 5). Fig. 5 shows that the nearest oil field is ~91 km from the trajectory in 2013 and ~21 km from the trajectory in 2014. The authors further stated that at this time, it is difficult to confirm whether the oil released in the vicinity of oil fields is due to field operations or natural seepage. This demands optimizing

the available resources for oil spill monitoring in the sea, from where the tarball pollution originated.

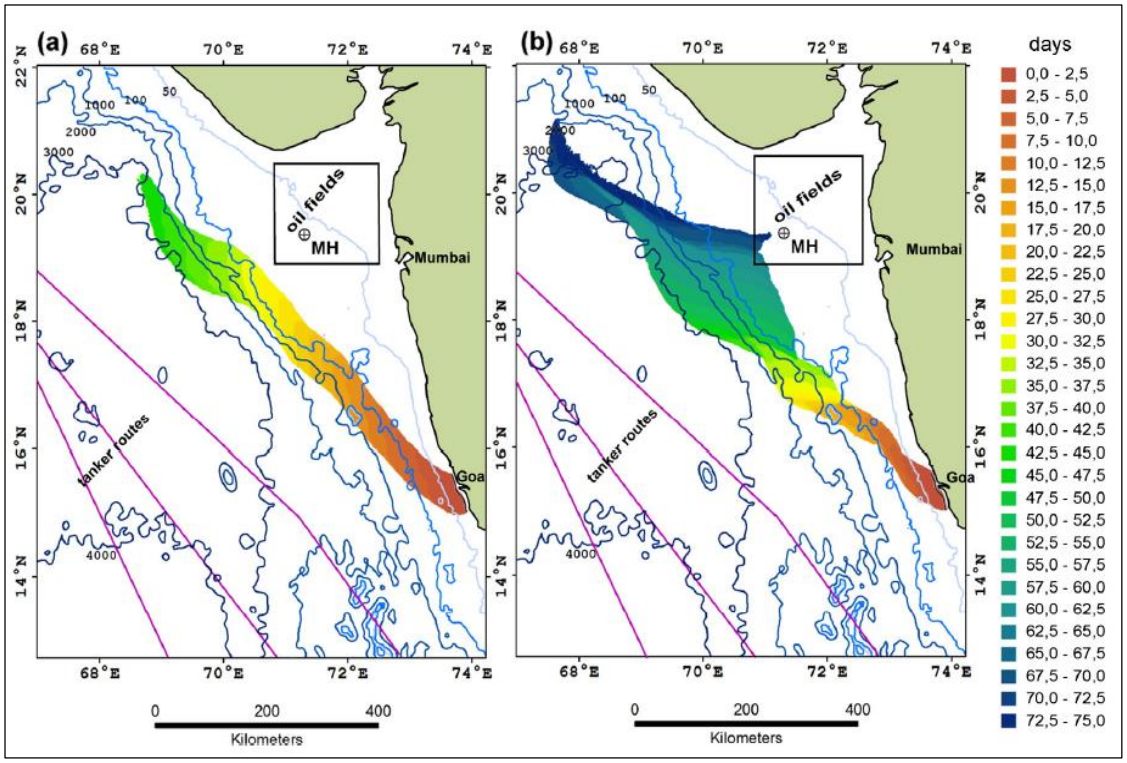

Figure 5. Trajectories of backtracking simulation for (a) May 2013 and (b) May 2014 (Source: Suneel et al. 2016)

1.1.3 Detection of oil slicks through remote sensing technique

Offshore oil pollution along the west coast of India (WCI) is a serious problem as is evident by the seasonal occurrence of tarball deposition on its beaches. Usually, large oil spills in the offshore region occur due to collision or grounding of ships/tankers or accidents at oil platforms and to protect the marine environment various spillage-restricting measures are immediately put into action by policymakers and stakeholders, at least before the spills reach the coast. However, when small spills occur routinely in the sea far from the coast, they go unidentified and unreported, and no precautionary measures are taken to rectify the damage caused by such oil spills. In the recent past, Suneel et al. (2019) have initiated an investigation program to

identify such undocumented spills that contribute to oil pollution along the WCI and Eastern Arabian Sea (EAS) using the remote sensing technique. The complete details of satellite imagery, image processing methodology are given in Annexure – A. The authorshave demonstrated the importance of such spills using Sentinel-1 SAR imagery data (270 images) acquired in 2017.

They found that occurrences of such oil spills were more frequent in the offshore regions of Gujarat (41.6%), Maharashtra (34.8%), and Goa-Karnataka (23.5%) coasts. Most of the spills that were detected off Gujarat and Karnataka coasts are primarily attributed to ship-based oil spills. The spills off the Maharashtra coast are attributed to both shipping activities as well as the discharge from oil fields. Active oil spills were observed consistently every month at three locations L1, L2, and L3 in the vicinity of oil fields off the Maharashtra Coast, and the locations L1 and L2 match very well with the locations of oil platforms BH, BHS, ICP, SHP, and NLM of Bombay High (Fig. 6). The chemical fingerprint and backward Lagrangian particle simulations have further confirmed that the oil spilled at those L1 and L2 sites are responsible for the formation of tarballs deposited along the Goa coast during May 2017. The authors have recommended that there is a need for routine and periodic monitoring of oil spills along the WCI to protect the marine environment from oil pollution.

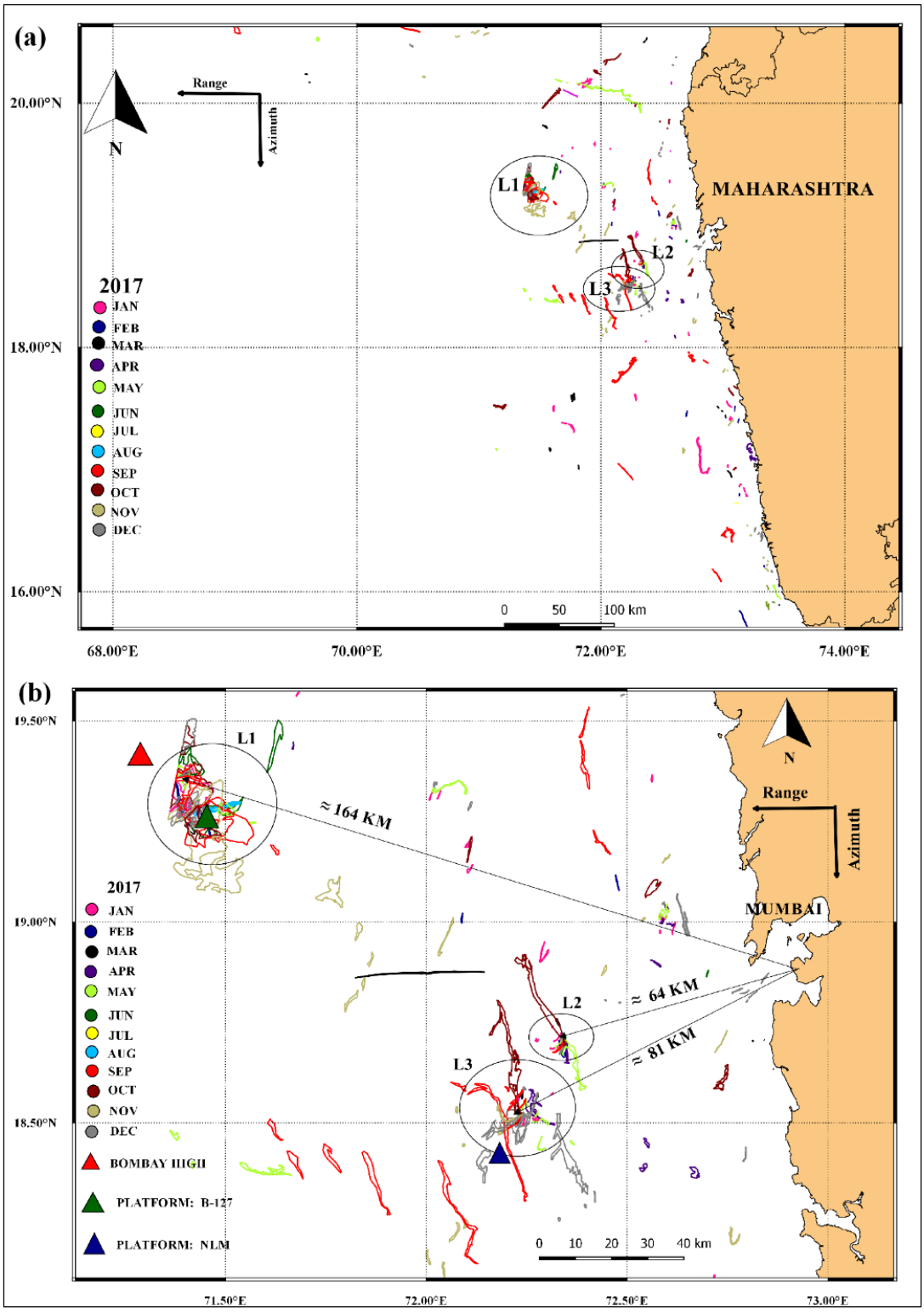

Figure 6. Shapefiles of detected oil spills off Mumbai. (a) The circles L1, L2, and L3 are the locations where repeated oil spills have occurred. (b) Zoomed view of L1, L2, and L3 locations. BH, BHS, ICP, SHP, and NLM are Bombay High platforms (Source: Suneel et al. 2019).

1.1.4 Fingerprinting of the source of the tarballs deposited along the Gujarat coast

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Deposition of tarballs along the south Gujarat coast was also often reported. Twelve tarball samples from four beaches Nargaol (NB1, NB2) and Umbergaon (UB1, UB2) on 15 July 2012 and Maroli (MB1, MB2), Tithal (TB1, TB2), Nargaol (NB3, NB4) and Umbergaon (UB3, UB4) on 17 July 2012 were collected with the help of Gujarat Pollution Control Board (GPCB) and transferred to CSIR-NIO for the fingerprint analysis. The complete methods for sample extraction, GCMS analysis, GC-IRMS analysis are explained in detail in Annexure - A.

Suneel et al. (2014) have conducted a multidisciplinary analysis to confirm the source oil with fingerprint technique and confirm the source location by using a Hydrodynamic (HD) model coupled with a Particle Analysis (PA) model. The analysis of n-alkanes, PAHs, and pentacyclic triterpanes, in conjunction with the Compound Specific Isotope Analysis (CSIA), was conducted for 12 tarball samples (from the south Gujarat coast), and five crude oil samples (expected sources) such as (i) two BH-based crude oils one from the MUT (Mumbai High Uran Trunk) oil pipeline (BHM) and the other from the HUT (Heera Uran Trunk) oil pipeline from the Heera offshore Platform (HUT); (ii) two crude oil samples produced off Gujarat coast, and operated by the Cairn (CRN) and Niko firms (NIK) and (iii) one crude oil sample collected from the vessel MSC Chitra (MSC) during its grounding (after collision with MV Khalijia-III on 07 Aug 2010, off Mumbai coast). The DRs of Pentacyclic triterpenes C_{29}/C_{30} and $\sum C_{31}$-C_{35}/C_{35}, called homohopane index, are reliable source identifiers (Zakaria et al. 2000, 2001, Chandru et al. 2008, Suneel et al. 2013, 2014). The cross plot between the DRs C_{29}/C_{30} and $\sum C_{31}$-C_{35}/C_{35} indicate that MECO, SEACO and MSC (red, pink and green circles in Fig. 7) do not match with the tarball DRs. Nevertheless, BHM and BHH crude oils are matching with the tarball (black circle in Fig. 7). The ranges of CRN and NIK are also very close to the tarballs (orange circle in Fig. 7). The Homohopane index cross plot conspicuously reveals that MECO, SEACO, and MSC crudes are not the sources for the formation of these tarballs.

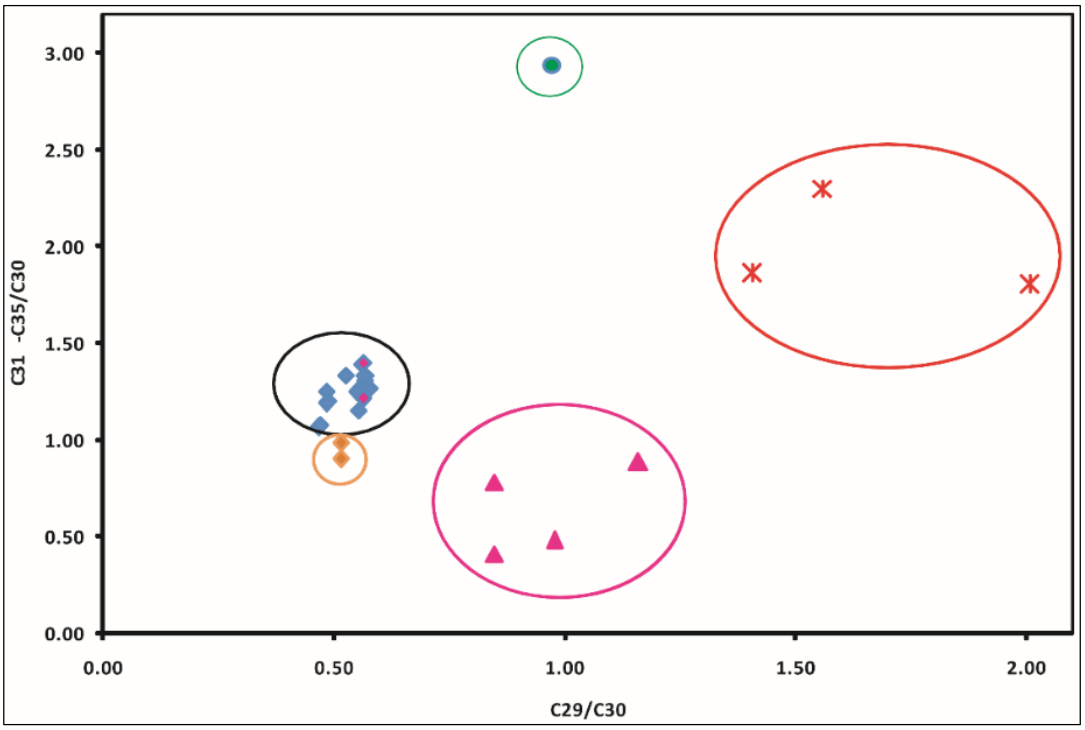

Figure 7. Cross plot of homohopane index. The red circle represents MECO, pink-SEACO, orange-CRN and NIK, green-MSC crude oil, and the black circle contains Tarballs (blue* color*) and BHH (pink* color *top), and BHM (pink* color *down) (Source: Suneel et al. 2014).

Thus, based on the DRs of pentacyclic triterpenes, Suneel et al. (2014) confirm that the tarball samples originated from the BH crude oils. However, a small error in data processing and calculation of DRs could influence the interpretation of the results. For example, the hopane DRs of CRN and NIK are nearly the same as the DRs of tarballs. Therefore, to confirm the source of tarball, authors have performed another diagnosis - the compound-specific isotope analysis (CSIA) for tarball samples and crude oils. Mansuy et al. (1997) confirmed that CSIA analyses with GC-IRMS are a more powerful tool to correlate the samples for the source oils.

The results of CSIA of n-alkanes in different tarballs and crude oils are depicted in Fig. 8. It is evident that the slope is steep and higher molecular alkanes are isotopically lighter than the lower molecular alkanes. In this study, we found that the $\delta^{13}C$ ratio lines of BHM and BHH are virtually identical to each other. The CRN and NIK also apparently follow identical patterns

(Fig. 8). This is because the BHM and BHH are generated from the same type of source rock and produced in the BH basin fields. Therefore, the $\delta^{13}C$ ratios are the same for these two crude oils. Likewise, CRN and NIK are also produced at offshore regions of the Gujarat coast. The distance between these two wells is more or less 10 km; therefore, both sources produced identical crude oil characteristics. However, there was a difference exists between BH-based crude oils and CRN /NIK-based crude oils. The $\delta^{13}C$ ratios of lower molecular components (C_{15}-C_{26}) of BH-based crude oils are isotopically higher compared to those of CRN and NIK crude oils, while the $\delta^{13}C$ ratio of higher molecular components (C_{26}-C_{35}) are lighter, but close to each other.

The case is reversed for MSC crude oil. The $\delta^{13}C$ ratios of alkanes beyond C_{20} are isotopically heavier than tarballs and BH, CRN, and NIK crude oils. Therefore, we confirm that MSC, CRN and NIK crude oils are not the sources for the tarballs deposited on the Gujarat coast. A good match exists between BH-based crude oils and the tarball samples; alkane $\delta^{13}C$ ratios follow the same pattern and are within the range of both the crude oils and tarballs. Thus CSIA analysis confirms that the source of the tarballs is BH-based crude oil (either BHM or BHH). A review work by Hunt et al. (2002) reveals that the combination of biomarker and stable isotope analysis can be used as a source correlation tool in the petroleum geochemistry field. Thus, based on the triterpene and CSIA analyses, the source belongs to BH crude (either BHH or BHM).

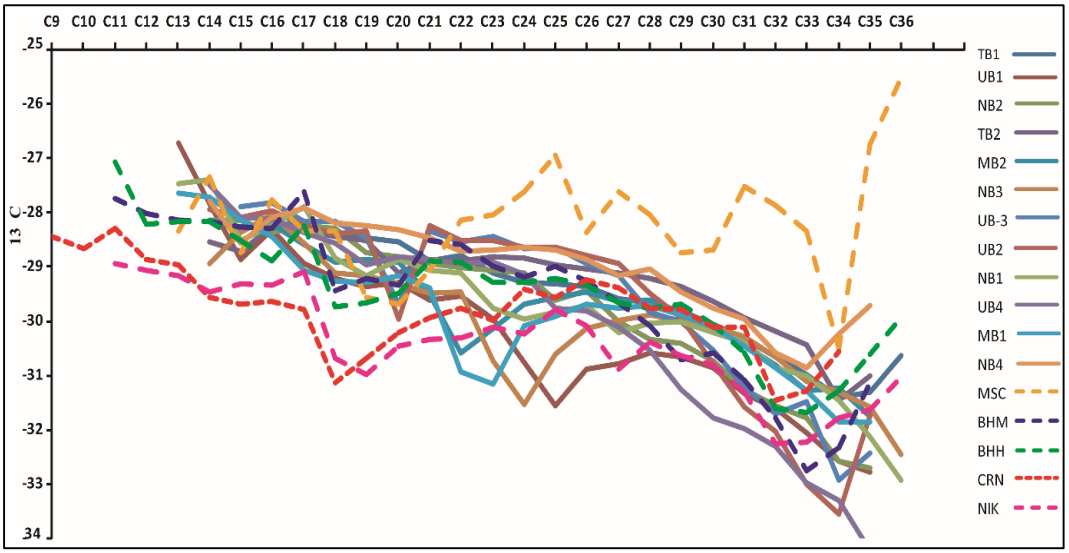

Figure 8. $\delta^{13}C$ ratios of different n-alkane components in tarballs and crude oils. The dashed lines are for crude oils (red -CRN; pink -NI; blue- BHM; green -BHH; and dark yellow -MSC); while the solid lines represent tarball samples (Suneel et al. 2014).

1.1.5 Simulation of tarball trajectories off the Gujarat coast (2012) using the Particle Analysis model

Utilizing the European Centre for Medium Weather Forecasting (ECMRF) re-analysis winds and MIKE 21 simulated Hydrodyamic currents as inputs, the simulation of the Particle Analysis model was carried out for the months of April, May, June and July 2012 to understand the forcing mechanism of tarball transport during 15-17 July 2012 along the Tithal, Maroli, Umbergaon and Nargol beaches of south Gujarat. The simulated trajectories are illustrated in Fig. 9. The particle trajectories during June and July are more or less similar but are entirely different from the April and May trajectories. June simulation (Fig. 9c) shows that a few particles initially travelled towards the east and directly reached the coast, while some turned towards the northeast and southeast (because of the local tide effect) and finally landed on the coast. Particles P4, P5, P6 and P7 landed along the coastal stretch between Tithal and Nargol after 17, 18, 20 and 18 days of release, respectively. During June, under the influence of winds (south-westerly) and currents (towards southeast), the TB particles take a resultant direction

towards the east-northeast. The winds and currents are more robust in July than in June, while the directions are the same. Particles P4, P5, and P6 precisely landed along the coastal stretch of Tithal, Maroli, and Umbergaon. The rest of the particles, P1 and P2 landed far north of Tithal, and P7, P8, P9, and P10 landed far south of the Nargol. Particles P4, P5, and P6 travelled for 15, 18, and 21 days to reach the coast on 10, 13, and 17 July 2012, respectively, and this reasonably matches with the tarball depositions that occurred during 15 -17 July 2012 along the beaches of Tithal, Maroli, Umbergaon, and Nargol. Based on the four months' simulations, the authors stated that tarball particles start moving from the region of origin during late May/June and take a turn towards either east or northeast and reach the coast.

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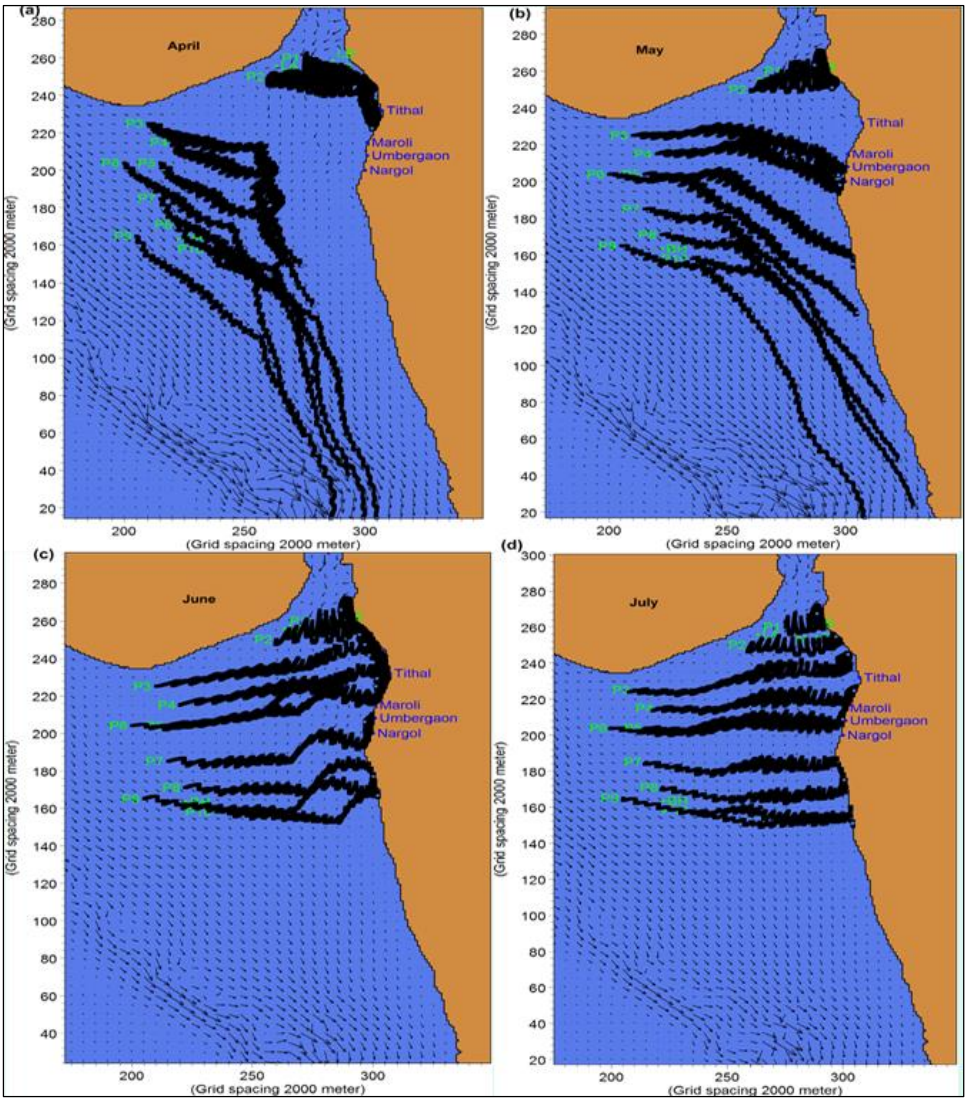

Figure 9. Simulated trajectories of tarball particles using the Particle Analysis model for (a) April, (b) May, (c) June, and (d) July 2012. (Source: Suneel et al. 2014).

From April to July, the mean surface current pattern in the domain is consistent, and it flows in the southeast direction. However, the winds change their direction such as north-westerly in April, westerlies in May, and south-westerlies in June and July. Therefore, the shift of trajectories from April to July must be primarily due to the influence of winds. During April and May, the particle trajectories are closely under the influence of currents (southeast), whereas in June and July, the strong south-westerly winds are more dominating forces than the surface currents. Therefore, the trajectories during June and July are toward the east and

northeast. The wider continental shelf (~250 km) has a depth of less than 200m and is dominated by tidal currents and winds. Thus, winds and tidal currents played a significant role together with the minor contribution of wind-driven currents in transporting tarballs to the south Gujarat coast during July 2012.

The Oil and Natural Gas Corporation (ONGC) has also undertaken oil spill modelling studies in November 2019 for Western offshore fields through a private external agency (M/s Environ Software Ltd.). Their trajectories also indicate that during monsoon season the oil sick moves towards the Gujarat and Maharashtra coast (shown only July simulation), supporting the Suneel et al. 2014 study explained in Fig. 9. Based on their pre-monsoon (showed only January scenario) and post-monsoon (showed only October scenario) simulations, the spill is not moving towards the Goa coast (simulations can be seen in **Annexure - B**). However, the simulations during the March, April, and May months (pre-monsoon, not provided) will definitely show the drift of the oil spill toward the Goa coast. The ONGC has not considered these months for the simulations.

1.1.6. Remote sensing of year-to-year variability of oil pollution along the eastern Arabian Sea

Recently, Trinadha Rao et al. (2022) acquired the Sentinel-1 satellite data (including 295 images) during the pre-monsoon (March-May) of the four consequent years from 2017 to 2020 to identify the undocumented oil spills. The data revealed that three oil spill hot spot zones along the west coast of India. The complete details of satellite imagery and image processing methodology are given in Annexure-A. They are named Zone 1 (Off the Gujarat coast), Zone 2 (Off the Maharashtra coast), and Zone 3 (Off the Karnataka and the Kerala coasts). The ship-based oil spills were dominant over zones 1 and 3, and the oil field-based dominance over zone 2. Those data further depict that the occurrence and abundance of oil spills were relatively low, within an area of 4.30 km^2 (only 1.2 %) during 2020; than those

found in other years over Zone 1. This suggests that fishing and other local cargo operations were on hold during the COVID-19 incident in India and that might have been conducive to fewer oil spills. Whereas, the year-to-year abundance of oil spills over zones 2 and 3 are not significantly varied (170.29 km^2 and 195.01 km^2), further suggesting the influence of oil exploration and international tanker traffic in operation even during COVID-19 lock-down periods in India.

The total number of oil slicks (Sentinel-1A) detected during pre-monsoon (March to May) of four consecutive years (2017, 2018, 2019, and 2020) along the west coast of India is depicted in Fig. 10. From the distribution of those oil spills along the WCI, it is evident that there are three discrete regions wherein the density of oil-spills is significant (black rectangular boxes in Fig. 10). Among those potential oil-spill hotspot zones, the Zone-1 is located in the offshore area of the Gulf of Kachchh, Gujarat; Zone-2 is located off Mumbai coast, Maharashtra; and Zone-3 is at offshore areas between south Karnataka and north Kerala coasts. During that survey period (March-May, 2017 to 2020), around Zone-1 off the Gujarat coast, nearly 52 numbers of oil slicks were found over a cumulative area of 356.6 km^2 (i.e., 17.56% of the total oil-affected area). Further south, Zone-2 off northern Maharashtra, displays the maximum number of oil slicks (176) covering a large area of 1022.1 km^2 (i.e., 59.45% of the total area), and within Zone-3 off Karnataka and Kerala coasts 68 number of oil slicks were found over an area of 475.9 km^2 (22.97%) (Fig. 10).

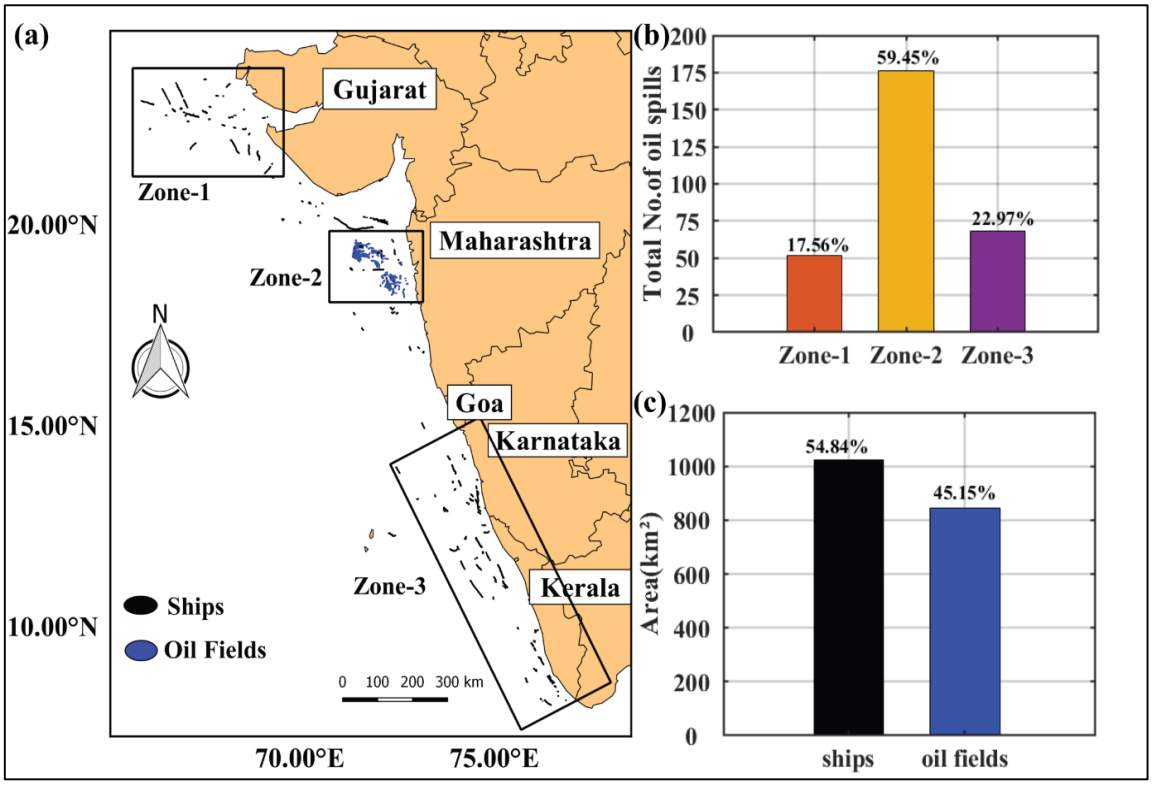

Figure 10. Oil spill distribution along the west coast of India during 2017-2020 (March to May). (a) The black square/rectangular boxes in the image indicate 03 potential oil-spill hotspot zones. (b) Graph showing the cumulative number of oil spills detected in those zones. (c) The major sources of those oil spills along the west coast of India. (Source: Trinadha Rao et al. 2022)

The physical features of all the oil spills identified over Zones 1 and 3 are quite similar; having almost straight and elongated shapes, relatively bright at one end of the slick, and they were not repeated geographically in the same place. These features confirm all these spills originated due to ship/boat activities (Suneel et al., 2019; Suresh et al., 2013). Thus, the oil spills in these two regions completely originate from ship-based sources. In contrast, the oil slicks detected over zone 2 are not elongated; they are slightly wider and longer with a bright spot at one end (Fig. SI. 4). Importantly, these oil slicks were also detected repeatedly at a few locations that match the geographical coordinates of a few oil fields. Thus, we confirm that most oil spills in this region (Zone-2) originated from oil field-based spillages. The occurrence of oil slicks is

higher at Zone 2, where the oil field-based slicks are abundant, followed by Zones 3 and 1. In terms of the type of oil spills, on the whole, the oil field-based slicks are more in number (total of 176 slicks during 2017-2020) than the ship-based oil spills (total of 120 slicks during 2017-2020). Surprisingly, the area occupied by the ship-based slicks is slightly higher (Area) (1024.80 km^2) than the oil field-based slicks (843.90 km^2) (Fig. 10c) in the EAS.

1.2 Conclusion

Based on all the above case studies (Fingerprinting, modelling, and remote sensing studies) in this chapter, it is evident that the occurrence of oil spills caused by ships and oil field explorations is significant in the Eastern Arabian Sea. Some of the tarball depositions that occurred in Goa and Gujarat identified their source as oil fields and ship-based too (only once). However, the source of tarball deposition may vary from year to year and from place to place based on the occurrence of the type of oil spill from which the tarball is formed.

India being a major importer of crude oils through tankers, is highly susceptible to the risk of oil spills. About 70% of the world's oil demand is ferried along the Indian Coastline, and the major Indian Ports handle over 7000 petroleum oil and lubricant tankers each year. Hence, it is recommended that the fingerprint data bank of all the crude oils from each oil field in the continental shelf region of the eastern Arabian Sea, and the Middle East and Southeast Asian crude oils that are being transported across the Arabian Sea through large tankers, and the crude oil sample from all the tankers that are berthing on the ports of west coast of India are need to be generated. This data will be useful for the source confirmation of tarball depositions that may occur in the future.

The Oil and Natural Gas Corporation Limited (ONGC) recommends the use of porphyrin compounds chelated with metals, such as Vanadium and Nickel which break down slowly in the Environment. The use of Ni/V ratios for tracing the source of oil spills/tarballs needs to be

explored. In addition, regular aerial surveys through either drones/or choppers, at least twice a week randomly are to be performed over the offshore development Area (offshore oil fields) off Maharashtra and Gujarat, and also other offshore regions along the west coast of India to monitor the unknown oil spills.

Objective 2: Review the current mechanism of addressing the tarball problem at Indian Coasts/beaches and identify gaps.

***2.1. Research and development*:**

To date, significant research has been conducted towards a better understanding of tarball pollution along the Indian coasts. This includes studying the source and transport patterns of tarballs, as well as developing more efficient methods for remedial measures. Suneel et al. (2013a, b; 2014; 2015; 2016; 2019) have carried out investigations for source identification through chemical fingerprinting, particle trajectory modelling, and satellite remote sensing techniques. The generation and comparison of diagnostic chemical features among oil samples (both spill and suspected source oils) and potentially impacted samples (shorelines, sediments, biological tissues or beached tarballs) is called "Fingerprinting" (Stout and Wang, 2007). The analyses of biomarkers, the groups of complex hydrocarbons play a key role in such environmental forensic investigations. These hydrocarbons are derived from the dead bodies of historic living organisms that are present in the source rock and parent organic molecules of oil/petroleum deposits. Those biomarkers present in petroleum and its products have characteristic features and are used for chemical fingerprinting, as they preserve most of the carbon skeletons of their original product. Over the last decades, such biomarker-based techniques for the identification of petroleum-derived contaminants in marine environments have been used in several studies (Bence et al., 1996; Boehm et al., 1997; Kvenvolden et al., 1995; Volkman et al., 1997; Wang et al., 1994a, 1994b, 1999; Zakaria et al., 2000, 2001). Particularly, the terpane and sterane biomarkers; which are less degradable and less prone to natural weathering as compared to n-alkanes and isoprenoid hydrocarbons (Volkman, 1984);

have been used as powerful tools for fingerprinting techniques to trace out the source of weathered oil in marine environment. Using these biomarker compounds, several tarball depositions from Goa and Gujarat in different years were fingerprinted (Suneel et al. 2013a, 2014, 2015). These results were described in detail in the previous section (i.e., Objective 1).

Certain micro-organisms including fungi and bacteria are known to utilize hydrocarbons present in tarballs as the sole source of carbon for nutrition. Few researchers have attempted to identify those fungi and bacteria associated with the tarballs. Sanyal et al. (2016) studied the diversity and genetic capabilities of tarball-associated microbes and characterized their phylogenetic diversity based on internal transcribed spacer (ITS) region sequencing analysis. Shinde et al. (2018) aimed to isolate both bacteria and fungi from tarballs collected from Betul Beach in south Goa and characterize their phylogenetic relationships based on 16S rRNA gene (for bacteria) and the ITS sequence data (for fungi) analyses. Their results reveal the presence of phylogenetically diverse 28 microbial genera (20 bacterial genera and 8 fungal genera) in those tarballs. Another study by Fernandes et al. (2019) identified the bacterial diversity associated with the tarballs deposited in the Vagator and Morjim beaches of north Goa. They reported that the Proteobacterial members were dominant in both Vagator (≥85.5%) and Morjim (≥94.0%) samples. Many of the identified taxa have been previously reported as hydrocarbon degraders (e.g. Halomonas, Marinobacter) or possible human pathogens (e.g. Acinetobacter, Klebsiella, Rhodococcus, Staphylococcus, Vibrio). Fernandes et al. (2020) reported the bacterial composition of tarball-contaminated seawater from Vagator beach, Goa, India, and characterized by amplicon sequencing of V3–V4 regions of the 16S rRNA gene. The DNA data revealed an unusual surge of Vibrio in seawater contaminated with tarballs

in May 2018 (16.16% OTUs), compared to tarball-free seawater samples collected in March 2018 (no detectable OTUs) and September 2018 (0.17% OTUs). The high abundance of Vibrio in the seawater contaminated with tarballs in May 2018 can be related to its versatile metabolic requirement and survival in limiting conditions (Thompson and Polz, 2006). With millions of tons of global oil seepage in the marine environment, this exposure may have made Vibrio species withstand and utilize the hydrocarbons.

The bioremediation of beached tarballs are promising natural process; that could protect the marine environment affected by tarball pollution. Shinde et al. (2017) highlighted the recent studies on tarball-associated bacteria and fungi and discussed about possible applications of those microbes in the bioremediation of beached tarballs. Raikar et al. (2001) reported that the growth of thraustochytrids was found to be very high in OZG (Oppenheimr-Zobell-Gaertner) and MV (Modified Vishniac's) media containing crude oil than the basal salt and basal mineral salt mediums. The authors claimed that the thraustochytrids isolated from coastal waters could degrade about 71% of tarballs in a month. Prakash et al. (2008) also reported that *Pseudomonas* sp. (Strain GUI13) capable of degradation of meta-toluic acid, a major component of tarballs. Rodrigues et al. (2010) reported a marine bacterium of genus *Alkaligenes* capable of degradation of dibenzothiophene, sulfur-containing polycyclic aromatic hydrocarbons present in tarballs. In India, the ‘oil zapper’ a consortium of oil-consuming bacteria has been used to remediate contaminated soils of oil refineries; dumped with oil sludge. This consortium of bacteria, mostly includes *Acinetobacter bauminii*, *Alcaligenes odorans*, *Bukhardica cepacer*, *Pseudomonas aeruginosa* and strain s-30 (Gupta et al., 2011). Shinde et al. (2020) a step ahead isolated eleven bacterial consortia from the tarballs deposited on the Goa coast and studied for their

capability towards the degradation of n-alkanes and polycyclic aromatic hydrocarbon compounds (PAHs) of tarballs following gravimetric and GC–MS–MS analyses. The experimental results showed those bacterial consortia reduce n-alkanes and PAH compounds by 53.69–97.78% and 22.78–61.98% respectively in tarballs, within 45 days. Bacterial consortium comprising *Pseudomonas* sp. *Betul-14*, *Betul-M*, and *Alcanivorax* sp. *Betul-O* exhibited promising tarball degradation abilities with 97.78% and 61.98% degradation of n-alkanes and PAH, respectively, within 45 days (Shinde et al. 2020). However, further research is required to obtain insights into degradation products and possible pathways involved.

2.2. Gaps and challenges

The fingerprint technique-based research carried out on tarballs deposited in Goa during 2013, and 2017 and in Gujarat during 2012, and 2013 reveals the spillage of oil from the oil fields as the sources (Suneel et al. 2013, 2014, 2015, and 2016). Likewise, the studies involving backtracking techniques on tarball trajectories also locate the same origin for tarballs deposited in Goa during 2013 and 2014. Later, Suneel et al. (2019) and, Trinadha Rao et al. (2022) depicted the occurrence of insignificant unknown oil spills along the eastern Arabian Sea and identified three oil spill hotspot zones off the Gulf of Kachchh, off Mumbai over the offshore development area (near oil fields), off Karnataka-Kerala coast through satellite remote sensing. However, the challenge still exists, regarding the nature of spillage, rate, and volume of oil spills, that occurred in oil fields. It is still not clear whether such spillages from oil fields are due to operational mismanagement or whether is it through leakages in the pipelines or related to natural oil seepage from the seafloor. Similarly, the oil spills due to shipping activities are also evident along the west coast of India. However, it is very difficult to identify the ship responsible for such oil spills in

offshore regions. But, any technique meeting such challenges could help to diminish oil pollution and eventually the formation of tarballs in coastal environments. The Oil and Natural Gas Corporation Limited (ONGC) recommends the use of porphyrin compounds chelated with metals, such as Vanadium and Nickel which break down slowly in the Environment. There are hardly any studies available nationally also internationally that recommend the use of Ni/V ratios for tracing the source of oil spills/tarballs. The use of Ni/V ratios for tracing the source of oil spills/tarballs needs to be explored.

Besides these, a few other lacking described below sections are also responsible for such pollution.

2.2.1 Insufficient clean-up infrastructure

Whenever tarball depositions occur in Goa beaches, the local Government agencies at local talukas deploy the manpower to clean the beaches manually with shovels. One of the significant gaps is the lack of adequate infrastructure for rapid and efficient tarball clean-up. Effective coordination and communication among various government agencies, environmental organizations, and local authorities are essential for timely and efficient response to tarball incidents. Delays in communication and therefore cleaning procedures could lead to further environmental damage. Proper equipment and resources are necessary to clean promptly and prevent the spread of tarballs from the affected coastline. Raising public awareness about the impact of tarballs on the environment and marine life is also very crucial. Beachgoers and local communities should be encouraged to report any tarball sightings to the appropriate authorities (Local district collector office) promptly. More campaigns and initiatives are needed to inform the general

public about the importance of reporting tarball sightings and supporting clean-up efforts.

2.2.2 Legal and enforcement issues

There might be challenges in enforcing environmental regulations and accountability in the parties responsible for oil spills; which leads to tarball pollution. Strengthening Infrastructure, human resources and effective enforcement of laws could help to address this issue. Legal and enforcement issues linked with clean-up at beaches also to be strengthened.

2.2.3 Impacts on Marine Ecosystems

Tarballs can produce long-lasting impacts on marine ecosystems, by affecting marine lives and coastal biodiversity. But there are hardly any studies were conducted on this subject along the Indian coast. Therefore, further research is highly necessary to assess the ecological consequences of tarball pollution and to develop appropriate preventive measures.

Objective 3: Suggest preventive measures required at source in respect of all scenarios, like the operation of offshore oil fields, ship leakages/discharges, oil spill events, etc., to minimize leakage of oil/petroleum materials and eventually lead to the formation of tarballs.

There are several useful preventive measures; that could be applied in the case of any leakage or spillage of oil into the marine environment. The details of some of those measures to minimize the impacts of oil spills are discussed in the following section**.**

3.1 Preventive measures required at oil fields

i. During drilling operations, well parameters should be continuously monitored and warning systems should exist to alert operators in case of any threat to well integrity. This real-time well monitoring information should often be displayed simultaneously in several locations, and examined by different teams of experts to ensure immediate mitigation of any deviation from normal operations as and when it is detected.

ii. *Oil water conditioner (OWC)*: This basic facility is mandatory for the treatment of effluent generated during the processing of oil at offshore platforms. The concentration of oil and grease in the treated effluent should be down to 40 ppm. In case it is disposed into the sea, it should not have more than 40 ppm of oil and grease.

iii. *Oil spill contingency plans*: In line with the National Oil Spill Disaster Contingency Plan (NOSDCP), an oil-spill contingency plan for each offshore development zone, should be made available based on the oil spill trajectory modelling studies conducted by any national oceanographic institutes.

iv. *Joint Inspection of Tier-1*: A committee consisting of the Indian Coast Guard, Pollution Control Boards, Oil Industry Safety Directorate (OISD), and other relevant National Research Laboratories may be constituted for the joint inspection of oil-spill response facilities and their operational capabilities at least once in a year.

v. Offshore personnel designated for handling oil-spill scenarios should be trained for IMO Level I, II, and III courses.

vi. *Periodic inspection and maintenance of oil pipelines to avoid any oil leakages*: Typical causes for any failure in the pipelines include human errors, such as anchor drags, misinterpretation of the control equipment readings and/or alarms, corrosion in the pipeline, defects during installation of pipelines, and flaws in the manufacturing process of pipelines as well as external geophysical factors. Therefore, there should be a standard procedure for the periodic inspection and maintenance of oil pipelines. In addition, the Leakage Detection System (LDS), Pipeline Intrusion Detection System (PIDS), and Corrosion survey in oil trunk pipelines must be in place to curb pipeline leakages and to assess the condition of the pipelines. For detailed SOPs please refer the Objective 6 in the following section.

vii. As a part of preparedness for mitigating any accidental spillage, regular oil spill mock drills around the oil field should be organized by the concerned OHA as per NOSDCP for the training of response personnel and evaluation of the contingency plan.

viii. Every oil field agency should be capable of handling the Tier-I oil spill (up to 700 tons of oil). The agencies are required to maintain Tier-1 oil spill response equipment and manpower. But for Tier-II oil spills (up to 10000 tons) and Tier-III (More than 10000 tons of oil) regional or national and if possible international assistance needs to be

obtained by all the agencies. Regular mock drills should be carried out for all 3 types of oil spill events.

ix. *Installation of alarms*: Sensor-based alarms should be installed to alert personnel in case of any spillage**.**

3.2 Implementing safety measures on ships

i. During any major ship accident involving a collision between ships, or grounding of the ship; there is a risk of oil spillage into the sea. To avoid such accidental spillage, ships/tankers must be double-hulled. Double hull on cargo/bunker can add a level of protection that reduces the likelihood and potential volume of oil spillage during an impact accident. In 1992, MARPOL was amended to make it mandatory for tankers of 5,000 dead weight and ordered after 6 July 1993 to be fitted with double hulls, or an alternative design approved by IMO in Annex I of MARPOL 73/78.

ii. The requirement for double hulls that applies to new tankers has also been applied to existing ships under a programme that began in 1995). In December 2003, further revisions to the requirements were made, accelerating further the phase-out schedule. These amendments entered into force on 5 April 2005. A new regulation on the prevention of oil pollution from oil tankers when carrying heavy grade oil (HGO) banned the carriage of HGO in single-hull tankers of 5,000 tonnes dwt and above after the date of entry into force of the regulation (5 April 2005), and in single-hull oil tankers of 600 tonnes dwt and above but less than 5,000 tonnes dwt, not later than the anniversary of their delivery date in 2008.

iii. Revised guidelines and specifications were adopted on 18th July 2003 for oil discharge and monitoring control systems for oil tankers. These Guidelines and

Specifications contain requirements regarding the design, installation, performance, and testing of oil discharge monitoring and control systems on oil tankers as required by regulation 15(3)(a) of Annex I of MARPOL 73/78. The requirements of Annex I of MARPOL 73/78 relating to oil content monitoring of oil tanker ballast and tank washing water are set out in regulation 15(3)(a). The regulaion stipulates that oil tankers of 150 tonnes gross tonnage and above should be equipped with an approved monitoring system and that such system should record continuously. (i) the discharge of oil in liters per nautical mile; and (ii) the total quantity of oil discharged, or alternatively, the oil content of the effluent and the rate of discharge.

iv. In both cases, the record should be identifiable as to time and date and should be kept for at least three years. Regulation 15 also stipulates that the system should come into operation when there is any discharge of effluent into the sea and should be such as will ensure that any discharge of oily mixture is automatically stopped when the instantaneous rate of discharge of oil exceeds that permitted by regulation 9(1)(a).

v. According to the IMO guidelines, all ships must include Automatic Identification System (AIS). In December 2000, IMO adopted mandatory requirements for the carriage of AIS, capable of providing information about the ship to other ships and coastal authorities automatically. The regulation in SOLAS chapter V indicates the Safety of navigation and requires AIS to be fitted on ships of 300 gross tonnages or more engaged in international voyages, cargo ships of 500 gross tonnages and more not engaged in international voyages and passenger ships of all sizes built on or after 1 July 2002.

vi. In case of any vessel accident, to diminish the risk of oil release, the vessel operators should exercise their vessel response plan (VRP) and alert not only the appropriate

Coast Guard authorities but also the salvage and marine firefighting force as recommended by authorities or included in their plan.

vii. All ships should follow safety protocols and measures to ensure that oil spills do not occur. According to the amended IMO resolution A.744(18), adopted in November 1993, all tankers and bulk carriers aged five years and more have been subject to a specially enhanced inspection program; to ensure the structural damages including corrosion or wear and tear resulting due to aging.

viii. *Regular maintenance:* All ships should be regularly inspected and maintained to ensure that all equipment and machines are in good working condition, and maintenance is carried out as per International Safety Management Code.

ix. *Training of crews*: Crews should be well-trained to recognize the signature of an oil spill in the marine environment and respond quickly and appropriately.

x. India is a signatory to the International Conventions on Pollution Prevention (MARPOL 73/78), preparedness and response as well as the International Convention on civil liability for oil pollution 1969, adopted by the United Nations Organization and its specialized agency in the Maritime Field International Maritime Organization (IMO). The provisions of many of these conventions have been incorporated in the Merchant Shipping Act, of 1958, and detailed technical standards and procedures for pollution prevention, and liability are addressed in the Merchant Shipping Rules framed under the Act. The technical standards suggest that the problem of oil pollution has to be undertaken in two stages viz. (i) Prevention of oil pollution, and (ii) Mitigation, containment/control, removal, or combat of oil spillage, whether accidental or otherwise.

xi. Prevention of oil pollution is tackled by the International Convention, Merchant Shipping Act, 1958, and M.S. (Prevention of Pollution of the Sea by Oil from Ships) Rules, 2010. These rules are applicable to all ships. The rules specify the limits of the prohibited zones, the equipment to be carried on board the ship and general precautions to be taken for the prevention of leakage and accidental discharges as well as precautions to be taken while loading, transferring, and unloading oil by tankers. The rules also require all vessels to maintain an oil records book to indicate any operations carried out on board with respect to oil. For mitigation and combating, oil pollution contingency plan of action has to be prepared so that in the event of any spillage whether accidental or otherwise, the same can be dealt with as per NOSDCP procedures.

xii. Tanks for oil residues or sludge: Every ship of four hundred gross tonnages and above should have a tank or tanks of adequate capacity, having regard to the type of machinery and length of voyage, to receive the oil residues or sludge, such as those resulting from the purification of fuel and lubricating oils and oil leakages in the machinery spaces, which cannot be dealt otherwise in accordance with the requirements of these rules.

xiii. Details of regular maintenance, SOPEPS, oil residues, discharge to authorized reception facilities, ballasting or cleaning of oil fuel tanks; discharge of dirty ballast or cleaning water from oil fuel tanks, collection and disposal of oil residues (sludge and other oil resudies), discharge overboard or disposal otherwise of bilge water which has accumulated in machinery spaces; and bunkering of fuel or bulk lubricating oil, etc. of ships on ports should be available on public display on port website (GSPCB).

xiv. MARPOL Standard Discharge Connection: To enable pipes of receptiona facilities to be connected with the ship's discharge pipeline for residues from machinery bilges and from sludge tanks, both lines shall be fitted with a standard discharge connection in accordance with the following table (Merchant Shipping Rules, 2010).

Table 1. Recommended dimensions of the discharge pipeline from machinery bilges and from sludge tanks (Merchant Shipping Rules, 2010).

Description	Dimension
Outside diameter	215 mm
Inner diameter	According to pipe's outside diameter
Bolt circle diameter	183 mm
Slots in flange	6 holes 22 mm in diameter equidistantly placed on a bolt circle of the above diameter, slotted to the flange periphery. The slot width to be 22 mm
Flange thickness	20 mm
Bolts and nuts: quantity, diameter	6, each of 20 mm in diameter and of suitable length
The flange shall be designed to accept pipes up to a maximum internal diameter of 125 mm and shall be of steel or other equivalent material having a flat face. This flange, together with a gasket of oil-proof material, shall be suitable for a service pressure of 6 kg/cm^2.	

xv. Oil Filtering Equipment: Any ship of four hundred gross tonnages (except hotel ships, storage vessel etc.,) and above but less than ten thousand gross tonnages shall be fitted with oil filtering equipment in accordance with rules as per Merchant Shipping (Prevention of Oil Pollution from ships) Rules 2020. Which indicates that oil filtering equipment shall be of a design approved by the Central Government and shall ensure

that any oily mixture discharged into the sea after passing through the system has an oil content not exceeding fifteen parts per million. In addition, it shall also be provided with arrangements to ensure that any discharge of oily mixtures is automatically stopped when the oil content of the effluent exceeds fifteen parts per million.

xvi. Control of Discharge of Oil: Any discharge of oil or oily mixtures into the sea from ships shall be prohibited except when all the following conditions are satisfied.

a. the ship is proceeding en-route
b. the oily mixture is processed through an oil filtering equipment
c. the oil content of the effluent without dilution does not exceed fifteen parts per million
d. the oily mixture does not originate from cargo pump-room bilges on oil tankers; and
e. the oily mixture, in case of oil tankers, is not mixed with oil cargo residues.

xvii. No discharge into the sea shall contain chemicals or other substances in quantities or concentrations, which are hazardous to the marine environment or chemicals or other substances introduced for the purpose of circumventing the conditions of discharge specified in these rules.

xviii. The oil residues, which cannot be discharged into the sea in compliance with this rule, shall be retained on board for subsequent discharge to reception facilities.

xix. Every oil tanker of one hundred and fifty gross tonnages and above and every ship of four hundred gross tonnages and above other than an oil tanker should maintain an Oil Record Book Part. Entries should be made on each occasion, on a tank-to-tank basis if appropriate, whenever any of the following machinery space operations take place in the ship, namely (a) ballasting or cleaning of oil fuel tanks; (b) discharge of

dirty ballast or cleaning water from oil fuel tanks. (c) collection and disposal of oil residues (sludge and other oil residues); (d) discharge overboard or disposal otherwise of bilge water which has accumulated in machinery spaces; and (e) bunkering of fuel or bulk lubricating oil.

xx. Double Hull and Double Bottom requirements for Oil Tankers delivered on or after 6th July 1996. This rule shall apply to oil tankers of six hundred tonnes deadweight and above delivered on or after 6th July 1996 (defined clause (36) of rule 1A).

3.3 Implementing safety measures in case of oil spill events

i. Oil spill scenarios, their potential impacts, suitable response options, and the effectiveness of those options vary greatly from spill to spill. Several response techniques may be employed during an oil spill to prevent its impacts on the natural environment (Fig. 11). These techniques include mechanical cleanup techniques to remove oil from the sea surface, application of dispersing agents, in situ burning of oil, various shoreline cleanup techniques, etc.

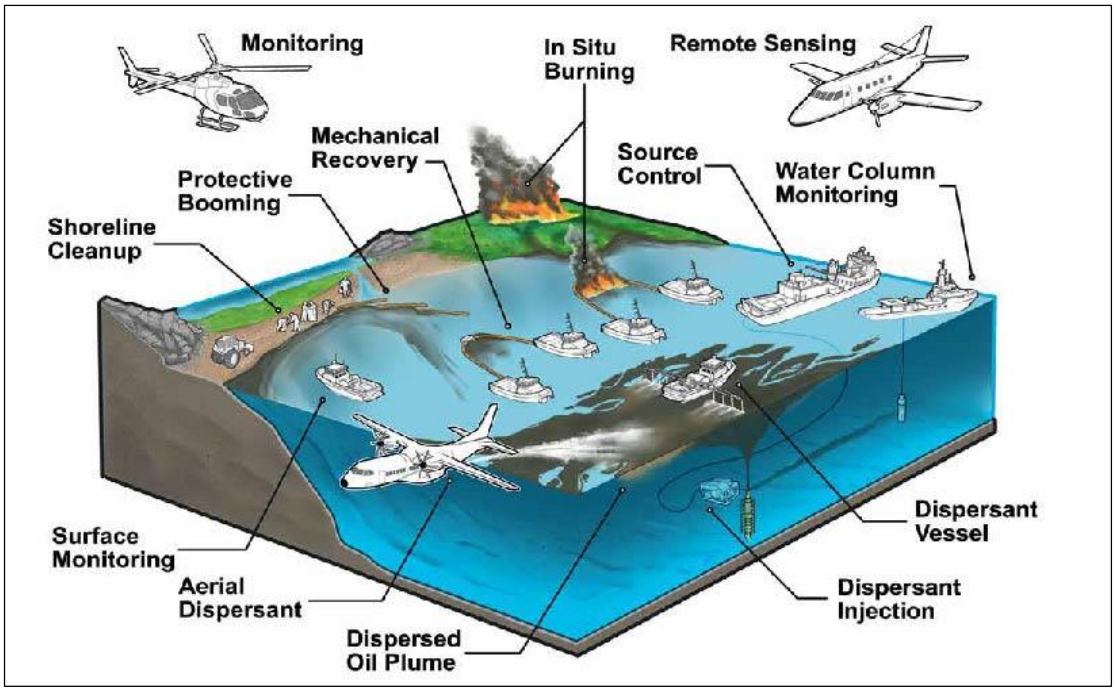

Figure 11. Oil spill response techniques and technologies. Courtesy: Oil in The Sea IV, Image provided courtesy of the American Petroleum Institute, produced by Iron Octopus Productions, Inc.

ii. Depending on the type of oil spill, the location of the spill, water depth, water and air temperature, wind speed, time of day, precipitation, etc., the specific response tools should be applied. For example, small to medium size spills of light fuel oil in offshore areas usually evaporate quickly and may not require any further actions. Allowing the oil to evaporate naturally and biodegrade without any application of additional response techniques could, under some circumstances, be the best-case solution.

iii. The advantages and disadvantages of different responses need to be weighed up and compared both with each other and with the advantages and disadvantages of natural clean-up to evolve a consensus for selecting the methodology of oil spill response and in defining the scope of implementation of the response. This process is known as Net Environmental Benefit Analysis (NEBA). The Net Environmental Benefit Analysis (NEBA) helps to protect people and the Environment. It is a process used by the response agencies to minimize the impacts of oil spills on people and the environment. It is important to have a plan in place in case of an oil spill event. This should include detailed information on the type of oil, the potential hazards, and the response measures.

iv. Preparation of a pre-spill NEBA by concerned authority can be considered to identify high risk areas of respective states (GSPCB).

3.1.1 Use of booms

The containment booms are used to control the spread of oil and thus to reduce the possibility of polluting shorelines and other resources, as well as to accumulate the dispersed oil in thicker surface layers, making recovery easier. In

addition, booms may be used to divert and channel oil slicks along desired paths, making them easier to remove from the surface of the seawater (Fig. 12).

3.3.2 Use of skimmers

Skimmers are mechanical devices that physically remove the free or contained oil from the surface of the water. There are many different types of skimmers but they can be grouped into different categories based on oil recovery principles. Weir skimmers, Oleophilic surface skimmers, and Hydrodynamic skimmers are the most common categories of skimmers. Each category of skimmer type is distinguished by their oil collection mechanisms as well as other factors. Mechanical recovery can be effective on small spills in calm waters, in areas where response can be assembled quickly.

Figure 12. Illustration of booms installed on the sea to contain the oil spill

Figure 13. Illustration of the removal of the oil layer through mechanical Skimmers. Picture credit: NOAA.

3.3.3 In situ burning of oil

In situ burning is a process of controlled burning of an oil slick in the field and it has been used as a response to countermeasure technique for more than 60 years. Fingas (2018) provides the most recent review of this technique. More recently, around 400 individual controlled burns were safely conducted during the

DWH response, removing an estimated 220,000 to 310,000 barrels of dispersed oil from sea surface in the Gulf of Mexico (Allen et al., 2011). Decades of research and field responses have proven that under favorable conditions, in situ burning can be a valuable response tool for removing large volumes of oil quickly, safely, and effectively with minimum environmental impacts. Successful in situ burning operations eliminates the need to collect, store, transport and dispose of recovered oil as required in the case of mechanical recovery. During slick combustion, liquid oil itself is not burning. The heat from an ignition source converts liquid hydrocarbons into vapors, which are then consumed by the fire. Once a small area of the slick is burning, heat from the flames will radiate to the adjacent oil, vaporize it into gas, and sustain the combustion process. The oil removal rate is a function of the oil type and its degree of weathering, burning area size, slick thickness, and environmental conditions.

3.3.4 Use of dispersants

Many international agencies and regulatory bodies around the world consider dispersants as the most practical spill response option. In many cases, dispersing oil into the marine environment can result in the lowest environmental impact. Chemical dispersants are used to break oil slicks into fine droplets; which disperse into the water column and undergo biodegradation by microorganisms in the sea. For this whole process, a clean-up team should be established to respond to the oil spill. The team should be equipped with all the necessary safety equipment. When successfully deployed, dispersants have the potential of removing floating oil from the surface of the sea and thus minimizing the impacts on marine communities. Dispersants can reduce the amount of oil reaching sensitive habitats such as Mangroves, Salt marshes, Coral reefs, and Kelp beds. Dispersants can reduce

impacts by lowering the adhesive properties of oil. It is best to disperse oil; before it approaches any important ecological habitats.

Figure 14. Illustration of spraying oil spill dispersants over the spill area

3.3.5 Use of oil-absorbent materials

Sorbents are used to recover small amounts of oil through absorption, the penetration of oil into the sorbent material, and/or adsorption, the adherence of oil onto the surface of sorbent material. To enhance recovery, most sorbents are both oleophilic (attract oil) and hydrophobic (repel water) in nature. In general, the use of sorbents is only appropriate during the final stages of cleanup or to aid in the removal of thin films of oil. Sorbents can also be used to clean up secondary spills and to protect and/or clean environmentally sensitive areas, such as turtle egg-laying areas or marshes, where the use of other cleaning methods is restricted as they could cause severe damage to those species.

Figure 15. Illustration of oil-absorbing material being deployed at sea

3.4 Classification of coastal environments and Environmental Sensitivity Index (ESI)

ESI maps have been used for oil spill contingency planning and response since 1979. ESI maps provide a succinct visual summary of natural resources, such as birds, shellfish, drinking water intakes, corals, and coastal recreational areas, that are at risk if oil is spilled in that geographic region. ESI maps help responders and planners determine the protection priorities.

3.5 *Monitoring and assessment*

Over the past two decades, significant advances in sensing instrumentation have occurred. In general, multiple sensors can be installed in any observing platform, and many sensors are suitable for multiple platforms. Platforms available in the toolbox for deploying sensors for visual and chemical observations on oil-spill; including moored instruments, equipment casts from the vessels, subsurface, and surface vessels, aircraft, and satellites. Aerial and surface remote sensing are the most often used methods in spill response measures. Through these observations Mapping and

documentation of the area, slick thickness, and percentage cover with time and space can be assessed.

3.6 *Shoreline protection and cleanup*

One of the impacts of discharges of oil into the marine environments is that it may eventually strand and, depending on the location, may affect open-water facing beaches and shores, rocky or vegetated shorelines, tidal flats, or manmade structures, such as rip-rap, jetties, or bulkheads. Once an oil slick arrives on shore, it may affect environmentally sensitive zones as well as areas, which are sociologically, economically, and culturally important to humans, for recreation, fishing, industry, and tourism. Depending on the character, type, and sensitivity of the shoreline and the physical and chemical properties of the oil (i.e., amount, type, and degree of weathering), various methodologies may be employed to mitigate an oiling event (NOAA, 2010). Oil deposited on a surface may be removed by manual methods such as a hand rake and shovel, sorbents, or by mechanical methods such as maintainers/ road graders and small front-end loaders, skimmers, and vacuum systems. The oil that has adhered to a substrate may necessarily use chemicals for removal or may be removed by the use of water washing utilizing varying degrees of pressure and temperatures.

Objective 4: Study of global practices on prevention of tarball formation and the measures taken to contain tarball pollution. Suggest viable mechanisms to arrest tarball at sea based on global practices.

Tarballs are sticky, semi-solid balls of petroleum residue that form after oil spills. Crude oil in any major oil spill undergoes natural weathering, a combination of processes, including spreading, evaporation, dissolution, biodegradation, emulsification, sedimentation, dispersion, oxidation, and leaves the residual part of spillage rich in dense, viscous oil components (NAS 2003); which mix with seawater to form a water-in-oil mixture. This weathered emulsion then breaks into pieces and thus forms pelagic tar balls or patties through various physical, chemical, and biological processes in the ocean (Warnock et al. 2014). Therefore, the best possible way to prevent tarball formation in the ocean is to prevent oil spills and to make immediate response activities in case of accidental oil spills.

4.1 Preventive measures to contain the tarball formation

4.1.1. Oil spill cleanup plan, response, and expert teams

Several countries and regions prone to oil spills have established oil spill response and cleanup plans. These plans usually depict the procedures for quick removal of spilled oil from the water surface before it undergoes weathering to form tarballs. For example, in North America, Environment Canada and the National Oceanic and Atmospheric Administration (NOAA) Office of Response & Restoration (OR&R) have developed similar Shoreline Cleanup Assessment Technique (SCAT) programs and associated products. The expert teams of SCAT are comprised of representatives from state and federal agencies, the Responsible Party (RP), and the U.S. Coast Guard (USCG) or U.S. Environmental Protection Agency (USEPA) as the Federal On-Scene Coordinator (FOSC). SCAT is multi-

agency, having trained representatives from all stakeholders, who have the authority to make decisions and provide a clear organizational framework for both cleanup decision-making and logistical coordination. In India, response to oil spill including shoreline cleanup is undertaken as per responsibilities allocated to various stake holders/government agencies in the NOSDCP. Therefore, local administration (or authorities) needs to sets up a Shoreline Response Centre (SRC) as per para 7.4 of NOSDCP and carry out shore line cleanup as per guidelines provided vide Appendix T of the NOSDCP. The creation of a multi-agency team, with trained representatives from different stakeholders may be more useful for quick response to any oil spills and cleanup procedures before the genesis of tar balls. As per para 2.2.2 of NOSDCP the State Government of a coastal state would constitute a State Level Crisis Management Group for management of oil pollution incidents, termed SOS-CMG. The shoreline response Centre (SRC) in coastal states may be equipped as required for effective and quick response to the oil spill/tar ball cleanup to mitigate further damage to sensitive marine environment.

4.1.2 Implementing Regulations

The government has passed laws and regulations to govern the shipping, offshore drilling, and petroleum industries to prevent oil spills. These regulations include strict measures to ensure companies follow safety protocols and implement the necessary measures for the prevention of spillage in the sea. All the oil spill preventive measures explained in Section 3 should be strictly followed during offshore drilling operations, in the shipping and other petroleum industries.

International Maritime Organization (IMO) is a specialized agency of the United Nations that focuses on the safety, security, and environmental protection

of international shipping. It has adopted several international conventions, including the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) and the International Convention for the Prevention of Pollution from Ships (MARPOL), which establish standards and guidelines for preventing and responding to marine oil pollution. MARPOL is the main international convention that covers the prevention of pollution of the marine environment by ships due to operational or accidental causes. The convention includes regulations aimed at preventing and minimizing pollution from ships. Currently, it includes six technical Annexes:

- *Annex I:* Regulations for the Prevention of Pollution by Oil
- *Annex II:* Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk.
- *Annex III:* Prevention of Pollution by Harmful Substances carried by Sea in Packed Form
- *Annex IV:* Prevention of Pollution by Sewage from Ships
- *Annex V:* Prevention of Pollution by Garbage from Ships
- *Annex VI:* Prevention of Air Pollution from Ships

Parties to OPRC are required to establish measures for dealing with pollution incidents, either nationally or in cooperation with other countries. According to this, ships are required to carry a shipboard oil pollution emergency plan. Operators of offshore units under the jurisdiction of Parties are also required to have oil pollution emergency plans or similar arrangements which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents. Ships are required to report incidents of pollution to coastal authorities and the

convention details of the actions that are then to be taken. Parties to the convention are required to assist others in the event of a pollution emergency and provision is made for the reimbursement of any assistance provided.

4.1.3 Contingency Plan and Environmental Impact Assessment:

Before undertaking any offshore drilling or major sea-based operations, companies are required to conduct environmental impact assessments (EIAs) and contingency plans. These assessments would evaluate the potential risks and also help to identify the measures essential for preventing and mitigating oil spills and tarball pollution. In India, the National Oil Spill Disaster Contingency Plan (NOS-DCP) is an action-oriented plan which covers various aspects such as reporting, communication, alerting, assessment, operations, administration, finances, public relations, and arrangements with other contiguous states. This plan assigns responsibility for various tasks to relevant government departments and agencies, to identify trained personnel, equipment, surface craft, and aircraft and depict possible means to access these resources or facilities. This plan also outlines the combined arrangements of stakeholders designed to allow rapid and cooperative response to marine oil spills within the defined area. These local plans provide detailed information on the local response to marine incidents and also describe the arrangements for mutual support. As a precautionary principle, all Indian oil tankers and ships are required to procure an International Oil Pollution Prevention Certificate (Section 356 C (1), The Merchant Shipping Act, 1958). Vessels carrying noxious liquid substances in bulk similarly require an International Pollution Prevention Certificate (Section 356 C (2), The Merchant Shipping Act, 1958). These certificates must be procured by the ships and oil tankers that are registered

outside India (Section 356 D, The Merchant Shipping Act, 1958). Usually, a Pollution Prevention Certificate is issued to any ship by the respective government; once the ship has been inspected and found to be amenable to the MARPOL Convention. Whenever an oil spill is suspected from a vessel, the Central Government may give notice to the owner of that ship/vessel (Section 356 J, The Merchant Shipping Act 1958).

4.1.4 Spill response equipment and training:

Organizations involved in marine operations, including shipping companies and offshore drilling operators, are required to maintain oil-spill response equipment onboard. They also should provide regular training to their personnel for operating that response equipment and managing spill-related emergencies at sea.

4.1.5 Improved tanker designs:

The shipping industry has made significant advancements in tanker design to minimize the risk of oil spills. Double-hull tankers, for example, are designed to provide an additional layer of protection against ship-based oil spills.

4.1.6. Use of oil spill dispersants:

In the case of oil spills in the sea, responders may use oil spill dispersants to break up the oil layers into smaller droplets, which are less likely to form tarballs. However, the use of dispersants requires careful consideration, as it can also produce adverse environmental consequences.

4.1.7 Monitoring and research:

Continuous monitoring of marine environments particularly in oil-spill-prone areas and research on oil-spill impacts would help to identify vulnerable areas and to improve the spill response and prevention strategies. IMO works with regional organizations, such as the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) and the Regional Marine Pollution Emergency Response Centre for the Caribbean Sea (REMPEITC-Caribe), to develop and implement regional agreements for the prevention and response to oil pollution. Under the Global Maritime Distress and Safety System (GMDSS), ships are required to report any incidents that may lead to pollution or other environmental hazards. In terms of reporting, Member States are required to provide information to IMO, directly or through the relevant regional organizations or arrangements. Therefore, in the Indian scenario, multi-agencies such as the OSID, DGH, DG Shipping, Indian Coast Guard, state and Central Pollution Control Boards, Ministry of Environment and Forest (MoEF&CC), Ministry of Petroleum and Natural Gas (MoPNG) should continuously work together to develop better preventive measures for oil pollution in the marine environment.

It's essential to emphasize that despite all these preventive measures, the risk of oil spills and tarball pollution remains a matter of concern. Therefore, a holistic approach that combines preventative actions with effective spill response and cleanup strategies is vital to protecting marine ecosystems and coastal environments from the devastating impacts of tarball pollution.

4.1.8 Suspended oil detection methods

Detection of oil films is an essential part of tracking submerged oil intrusion layers during an oil spill response. Fast, efficient, and accurate detection with quantitative measurements of the oil components is required to estimate the ecological risks of oil spill contamination. It also helps to confirm the location, time and mode of response plans to carry out against any oil spill event. Scientists use a variety of oil spill detection technologies to determine the location of the oil released, evaluate its degree of spreading, and identify the composition of the oil. The in situ observations with remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), and submarines help to locate oil and monitor its impacts in the water column and on the seafloor (Wilson et al., 2017). Submarine devices like gliders, deep submerged vehicles, and ship-lowered rosettes with in situ sensors and cameras are often used to detect submerged oil in real time (Table 2). Different sensors can be used to measure CDOM (coloured dissolved organic matter), PAHs (polycyclic aromatic hydrocarbon), and DO (dissolved oxygen) as proxies for submerged oil. These in situ measurements provide valuable information on the real-time distribution of submerged oil.

During the Deepwater Horizon (DWH) oil spill, ROVs inspected the rig, treated the underwater oil plume with dispersants, and studied the impacts of the oil on the seafloor environment. On April 22, 2010, ROV observation near the wellhead located about a mile below the ocean's surface found hydrocarbons leaking from the riser pipe. During that ROV-based observation, the blowout preventer was activated and scientists discovered other oil leaks. The videos obtained from ROV showed oil exiting the wellhead. They also collected oil samples and injected dispersants directly into the oil coming out of the wellhead.

In addition, the Scientists also deployed the AUV Sentry during two research cruises to track the underwater oil plume and to map and photograph deep-sea animals. The Sentry was equipped with multiple sensors including a mass spectrometer that helped detect the underwater oil plume at a depth of 3280 feet (Wilson et al., 2017).

Table 2. Summary of available sensors/cameras/equipment for in situ submerged oil detection (Ji et al., 2020).

Proxy of Submerged Oil		
Measurement	**Function**	**Sensors**
DO (Dissolved Oxygen)	DO deficit is calculated as a proxy for biodegraded oil	DO sensors: TETHYS, Sea-Bird SBE43, Aanderaa, Optode
CTD (Conductivity/Temperature/Depth)	The density profile can be derived based on the salinity and temperature	CTD sensor: Neil Brown Ocean, Sea-Bird SBE49 CTD, Sea-Bird SBE3
Oil droplets (size distribution)	Oil droplet size distribution measurement	Camera: Holocam, SilCam, High-speed camera systems
C_1-C_4 hydrocarbon, benzene, naphthalene	Reveal the distribution of dissolved hydrocarbon	MS sensor: TETHYS
PAH (Polycyclic Aromatic Hydrocarbons)	Measure the dissolved oil	Fluorometer
CDOM (Colored Dissolved Organic Matter)	Measure the refined hydrocarbon or crude hydrocarbon	CDOM fluorometer
Onboard Hydrocarbon Detection		
Measurement	**Function**	**Devices**
TPAH (Total Polycyclic Aromatic Hydrocarbons), PAHs, VOCs, aliphatic hydrocarbons; monocyclic aromatic hydrocarbons; biomarker	Detailed chemical characterization of dissolved oil and biomarker concentration	Onboard GC-MS (Gas Chromatography-Mass Spectroscopy) with FID (Flame Ionization Detector)
Dispersant constituents	Detailed chemical characterization of dispersant concentration	

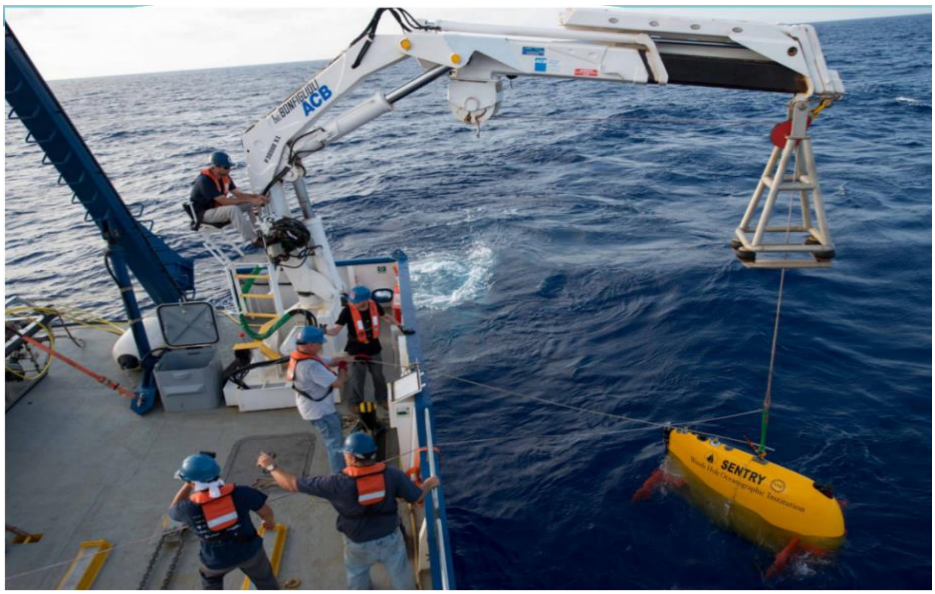

Figure 16. Launching of the AUV Sentry to track the sub-surface oil plume of the Deepwater Horizon oil spill (Wilson et al. 2017).

4.2 Suggest viable mechanisms to arrest tarball at sea based on global practices

Arresting tarballs at sea involves implementing mechanisms and technologies to collect, and remove tarball pollution from the marine environment before it causes further harm to the ecosystem. To our knowledge, there are no such mechanisms to arrest tarball at sea even on the global scale. However, some of the techniques discussed below can be useful up to a certain level to contain the tarball pollution at sea.

4.2.1 Shore sealing booms

Shore sealing booms are air and water-filled booms that are ideally used to seal the land and water connection, thus forming a temporary shore. Therefore, if we know that the oil spill/tarballs are arriving at a particular coast or beach or marine sensitive zones, we can deploy these booms to restrict their depositions on the shore. Subsequently, the same be collected and disposed of.

4.2.2 Aerial Surveillance and Response

Aerial surveillance using choppers or drones is an advanced monitoring technology commonly used to monitor oil spills over large areas in the sea. By implementing this monitoring technology we can detect the floating tarballs, their movement, and trajectories. This information allows for quick response coordination and timely deployment of containment and clean-up facilities. However, such an aerial survey cannot detect sunken or suspended tarballs and therefore, this method can be opted only for the floating tarballs, if they are visible.

4.2.3. Bioremediation

In some cases, bioremediation techniques can be used to facilitate the natural degradation of tarballs in the sea by introducing microorganisms that break down the

hydrocarbons. Normally the bioremediation of hydrocarbon-contaminated sludge is carried out in non-turbulent conditions. Hence application in the Sea may not be feasible based on the available technology today. The research on this aspect is still ongoing. However, few studies have identified efficient hydrocarbon-degrading bacteria, based on Laboratory studies (please see section 2.1). Hence application of those microorganisms for bioremediation could be a useful mechanism to contain marine tarball pollution. All these above-mentioned practices could be part of a comprehensive oil spill response strategy. It's essential to have well-prepared contingency plans, trained personnel, and adequate resources in place to effectively implement these mechanisms and minimize the environmental impact of tarball pollution in the sea.

The Goa State Oil Spill Disaster Contingency Plan (SOS-DCP) outlines initiatives and responsibilities for responding to oil spills or oil spill-related concerns (e.g. tarballs) along the coastal and shoreline areas, to prevent or minimize the effects of environmental pollution as a result of the oil spill as well as, respond to the oil spill in an environment-friendly manner and dispose of the collected oil/debris in accordance to the existing laws/regulations/orders in force. Similarly, all the coastal states need to develop effective response plans as per NOSDCP and maintain adequate trained personnel suitably equipped to undertake shoreline clean-up as a quick response measure.

Objective 5: Administrative and technical frameworks for monitoring tarball pollution under relevant statutes, in line with the allocation of business rules of various nodal agencies.

In an Office Memorandum of the Ministry of Defence dated 07 March 1986 and in the amendment to the Government of India (Allocation of Business) Rules, 1961 vide Gazette notification dated 12 December 2002, the Indian Coast Guard (ICG) has been designated as the Central coordinating authority for combating oil spills in the Indian waters and for undertaking oil-spill prevention and control. Accordingly, the National Oil Spill Disaster Contingency Plan (NOS-DCP) was prepared by the Indian Coast Guard and thus allocated different functional responsibilities to the various Ministries and Departments of the Government of India for oil spill response in the maritime zones of India. This plan was approved by a Committee of Secretaries to the Government of India on 04 November 1993 (NOS-DCP, 2015). Since then the NOS-DCP has been updated by the ICG several times, and the recent version which was released in 2015 is referred for this project to frame the allocation of business rules to various nodal agencies. According to section 1.6, this contingency plan applies to all incidents of marine casualty or acts relating to such casualty occurring with severe and imminent danger to the Indian coastline or related interests from pollution or threat of pollution in the sea by the deliberate, negligent, or accidental release of oil, ballast water, noxious liquid, and other harmful substances into the sea including such incidents occurring on the high seas. This also covers all incidents in any part of the sea, or inland, that are likely to affect the maritime zones of India, including all the territorial waters and the Exclusive Economic Zone (EEZ) of India and the High Seas where an oil or chemical spill has the potential to impact on Indian interests in the maritime zones of India.

As per the amendment to the Allocation of Business Rules of 12 December 2002, the responsibilities of the Ministry of Defence through the Indian Coast Guard include the matters related to:

a. Central Coordinating Agency for combating oil pollution in various maritime zones;
b. Implementation of a national contingency plan for oil spill disasters;
c. Surveillance of maritime zones for oil spills;
d. Combating oil spills in various maritime zones except within the jurisdiction of ports and oil installations; and
e. Undertaking oil spill prevention and control, inspection of ships (except within ports) and offshore platforms in the country.

Section 3.2.2 of NOS-DCP also indicates that the Indian Coast Guard (ICG) is responsible for acting as the Central Coordinating Agency to combat oil pollution in various maritime zones, except in the waters of ports and within 500 meters of offshore oil exploration platforms, coastal refineries, and associated facilities such as single buoy mooring, crude oil terminal, and pipelines. Section 3.2.4 and 3.3.15 of NOSDCP describe the responsibilities of State Government and Pollution Control Boards for shoreline cleanup.

In the case of oil spill events, the responsibilities in Indian waters are shared between the Indian Coast Guard, State Governments, Port Authorities, local corporations, and the oil industry. Statutory Agencies supported by combat agencies are primarily responsible for ensuring that contingency plans are developed for national, state, regional, and local levels. The following tables (Table 3) give detailed information on the combat agencies responsible for the clean-up of oil spills at different sources.

Table 3. Combat agencies responsible for clean-ups of oil spills that occurred in different sources (Source: NOSDCP, 2015)

Source/Location	Combat Agency
At oil terminals	The relevant oil company or terminal operator using industry mutual-aid arrangements as required. Should a situation develop where the necessary response is beyond the oil company terminal resources, or mutual-aid arrangements, responsibility for control will transfer to the Statutory Agency, with response assistance from other National Plan stakeholders as required
In ports	The port operator or responsible State Government authority, with response assistance from other national plan stakeholders as required.
Within shoreline and in intertidal zones	The responsible state Government authority and National Plan Stakeholders as required.
Beyond baseline	The Ministry of Defence via the Indian Coast Guard, with response assistance from other National Plan stakeholders as required. In incidents close to shore when oil is likely to impact the shoreline, the State Government via the Statutory Agency will be the Combat Agency for protecting the coastline, whilst DG Shipping assumes responsibility for ship operational matters, for example, containing the oil within the ship, organizing salvage, etc.
Spills emanating from offshore petroleum ops	The relevant company with assistance from the Statutory Agency and other National Plan stakeholders as required

Combat agencies have the operational responsibility to take action and respond to an oil spill in the marine environment following the relevant contingency plan. Separate, but linked emergency response units would direct operations in the event of an incident requiring response

under this plan. However, it is learned that there are no such contingency plans prepared to deal with tarball pollution. The following table (Table. 4) gives detailed information on various departments and their role when oil spill incidents occur, as suggested by the (NOSDCP, 2015).

Table 4. Combat agencies responsible for clean-ups of oil spills that occurred in different sources (Source: NOSDCP, 2015)

AGENCIES	ROLES
MINISTRY OF DEFENCE	The Ministry of Defence with administrative responsibility for the Coast Guard organization is the Ministry responsible for the central coordination of oil spills of national significance in the coastal and marine environment of various maritime zones.
INDIAN COAST GUARD	The Indian Coast Guard (ICG) is responsible for maintaining and implementing the National Oil Spill Disaster Contingency Plan (NOSDCP). The Indian Coast Guard is also responsible for acting as the Central Coordinating Agency for combating oil pollution in various maritime zones, except in the waters of ports and within five hundred meters of offshore exploration and production platforms, coastal refineries, and associated facilities such as single buoy mooring, crude oil terminal, and pipelines. As the Central Coordinating Authority for combating oil pollution, the Coast Guard will additionally: - a. Review the progress reports submitted by the State Crisis Management Groups

	b. Respond to queries addressed to it by the State Crisis Management Groups and the District Crisis Management Groups Publish a state-wise list of experts and officials who are concerned" with the handling of oil pollution incidents
MINISTRIES AND DEPARTMENTS OF THE GOVERNMENT OF INDIA	As outlined in section 1.1 of NOS-DCP, 2015, an executive decision of the Committee of Secretaries on 04 November 1993 serves as the reference for obligations of the various Ministries and Departments of the Government of India in support of the NOS-DCP. The agreed functional responsibilities are in Appendix A of the NOS-DCP, 2015.
STATE GOVERNMENT	The State Governments of coastal states are responsible for coordinating the district and local administration and operation of the National Plan for shoreline response and as per the provisions of the National Disaster Management Act, 2005. The State and District Authorities will provide a wide range of site-specific information and resources, either in relation to environmental impacts, or response activities through authorities, such as Transport, Conservation and Resource Management Departments, Environmental Protection Authorities, emergency services, port/harbor authorities, and local conservation groups.

SUPPORT AGENCIES	The responsibilities allocated to various support agencies for the implementation of the National Oil Spill Disaster Contingency Plan are described below. The Navy/ coastal state authorities/ port authorities will make their communication/ operation centres facilities available to receive and disseminate reports of marine pollution accidents. The Indian Navy and the Indian Air Force will provide fixed-wing aircraft or helicopters to conduct aerial surveillance or provide logistic support in the movement of men and materials to the incident site. They will also provide ground-to-air communication links at the site for use by the on-scene Commander. The Port Authority will provide tugs and pollution control equipment at the incident site within port limits. The Ministry of Shipping and Ministry of Petroleum and Natural Gas will provide tankers or tank barges for storage of recovered oil or oil in water emulsions and will arrange for storage and eventual disposal of recovered oil. The Director General of Shipping, Ministry of Shipping, will be responsible for all negotiations with the vessel, cargo owners, and insurers and will also conduct all negotiations regarding compensations and indemnification. The Ministry of Environment, Forest, and Climate Change and Ministry of Agriculture will provide scientific advice regarding species at risk, shore-line sensitivity, restriction of fishing activities, use of dispersant chemicals, beach cleaning methods, etc.

	The Ministry of Finance will provide authorisation for expenditure and funds for initial response and ensure adequate financial records are maintained. Coastal state authorities/ district administration/ departments/ public works/ civil defence corps will provide personnel and equipment, as required, for shoreline clean-up and ensure safety and protection of the local population and resources

Specialist technical advice is available to response managers from a variety of sources. Advice can vary from the fate of oil, selection and deployment of pollution control equipment, and dispersant use to the associated environmental effects of an oil spill. Specialist advice can also be provided in relation to the safety and stability of ships. The range of specialist environmental and operational technical advice in the event of an oil spill in the marine environment that can be provided by varied departments and organizations of the Government of India and other agencies is enumerated in the Table 5 (NOSDCP, 2015).

Table 5. Specialist Advice and Assistance of various agencies (Section 3.3, NOS-DCP, 2015)

AGENCIES	ROLES
DIRECTORATE GENERAL OF SHIPPING	a. Issuance of statutory notice to the polluting ship as per the provision of the Merchant Shipping Act, 1958. b. Invoking relevant provisions of the Merchant Shipping Act, 1958 in case the polluting ship fails to take action as required by the act to prevent or minimize pollution. c. Advising concerned affected ports or other entities to deal with evidence for the purpose of raising claims on accounts of damage caused by the pollution and initiating legal action against the polluter.

	d. Reporting such incidents to the Flag State of the ship or the neighboring coastal state that is affected due to pollution. e. Supervising salvage operations while dealing with oil pollution casualty if requested by the affected ports or other entities. f. Investigating oil pollution contravention under the provisions of the MS Act, 1958. g. To keep the Ministry of Shipping, Government of India, and other concerned authorities posted on the pollution, action taken, a progress report on combating, and follow-up action till normalcy of the situation. h. To advise the Indian Coast Guard on pollution-related matters under the provision of the Merchant Shipping Act, 1958 whenever requested. i. To take administrative and legal action for processing claims against damages incurred by the Coast Guard and other agencies relating to any other oil pollution incidents. j. Advise concerned agencies to collect evidence for the purpose of claims of pollution ships. k. To advise the receiver of the wreck with respect to the pollution aspect and response. l. To advise Indian ship-owners to mobilize ships for the purpose of oil trans-shipment if required.
INDIAN REGISTER OF SHIPPING	a. To provide advice relating to ship safety, structural integrity, and stability of marine casualties. b. To depute representatives to attend to a casualty and salvage at the SMCU when established.
MARITIME RESCUE CO-ORDINATION CENTRE	a. In addition to coordinating the rescue and saving of lives, to provide drift calculations and advice on offshore currents. c. Enabling messages to be communicated directly to vessels, during an incident, with its range of communication facilities including International Maritime Satellite (INMARSAT) systems.

DG SHIPPING COMMUNICATION CENTRE	a. To provide advice relating to ship safety, structural integrity, and stability of marine casualties and other details of the ship through coordination established with the Flag State of the stricken vessel.
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE	a. To develop and implement national policy, programs, and legislation to protect and conserve India's natural environment including regulation of dumping of wastes at sea, declaration and management of marine protected areas in Indian waters, and conservation of listed threatened, migratory, and marine species. b. To advise on matters relating to the Environment Protection from Dumping at Sea including the permitting and reporting of emergency dumping of material at sea. c. To advise on the potential impacts of oil spills on threatened marine and migratory species, such as seabirds, marine turtles, whales, and dolphins. d. To advise on the likely impact of oil spills on marine protected areas in Indian waters. e. To provide advice on habitats in marine protected areas, seabirds, marine mammals, marine invertebrates, and macro-algae, along with advice on rates of hydrocarbon biodegradation, dispersal, and the use of dispersants. f. To determine policy for the usage of dispersants in the sea areas of the territorial waters over which the state exercises jurisdiction.
ARCHEOLOGICAL SURVEY OF INDIA	a. Conduct underwater archaeological studies in Indian Waters. b. Assist/ advise in the protection and maintenance of the cultural heritage of the nation near to shore. c. Documentation of underwater sites and ancient shipwrecks

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES	a. To provide ocean state forecast. b. b. To provide software-based prediction of the trajectory of spilled oil.
INDIAN NAVY	a. Augment aerial surveillance capability of the Coast Guard as necessary in the area when an oil spill has occurred. b. To make arrangements for oil trans-shipment operations from any tanker that has caused or is causing or is expected to cause oil spillage. c. Promulgate general cautionary messages.
INDIAN AIR FORCE	a. Augment aerial surveillance capability of the Coast Guard as necessary in the area when an oil spill has occurred. b. To make available its aircraft for aerial monitoring of spills, aerial spraying of oil spill dispersants and mobilization of response resources
MINISTRY OF EARTH SCIENCES/ NATIONAL INSTITUTE OF OCEANOGRAPHY	a. Mapping of ecologically sensitive areas in the coastal and offshore region in consultation with the Ministry of Environment and Forests. b. Review of the sensitivity mapping listed by other agencies. c. To organize research on the impact of pollution on marine life based on actual oil pollution incidents.
MINISTRY OF AGRICULTURE/ DEPARTMENT OF ANIMAL HUSBANDRY, DAIRYING AND FISHERIES	a. To arrange for suitable fishing vessels on which oil dispersant equipment can be mounted if the local action group concerned is unable to mobilize this requirement locally. b. Sensitivity mapping of the sea areas, particularly within the territorial waters with specific information on fish breeding grounds. c. To provide a Fishery Survey of India's vessels for spraying of oil spill dispersants or other response measures.

MINISTRY OF PETROLEUM AND NATURAL GAS AND OIL AGENCIES	a. To assist, when required, in consultation with DG Shipping, with chartering of tanker/s for oil transhipment operations. b. To make available anti-pollution equipment and chemicals as are available with them. c. To assist in the storage ashore of oil transhipped from a wrecked or damaged tanker. d. To assist in the assessment of the value of the oil transhipped. e. To provide equipment and personnel resources and advice on a range of issues, including oil characteristics and local industry resource availability. f. To depute an Industry Adviser to the MRC during response to a major oil spill.
SHIPPING CORPORATION OF INDIA	a. To arrange for tankers or ships or tank barges for transport and collection of recovered oil. b. To arrange for any personnel required to assist with oil trans-shipment operation or to assist otherwise as may be required
MAJOR PORTS/NON-MAJOR PORTS/OIL TERMINALS/OIL INSTALLATIONS/SPM OPERATORS	a. To be in charge of the overall coordination of oil pollution response actions in the jurisdiction. b. To identify suitable tugs, vessels, and crafts when required for the operations. c. To identify surface crafts, on which dispersant spraying equipment can be mounted, and which can be used for rigging the boom. d. To ensure that for the purpose of part XIII of the Merchant Shipping Act, 1958, actions are taken by the various authorities under the overall legal responsibility of the receiver of wrecks. e. To ensure that at least the minimum equipment is kept available locally at all times. f. To arrange for training of personnel expected to be engaged in the above operations.

	g. To arrange for periodical mock drills and exercises so as to keep equipment and personnel on continuous readiness for oil spill response operations. h. To consult the ICG, DG Shipping, OISD or other authority, when further advice/ assistance is required. i. To keep the ICG apprised of actions being taken.
COASTAL STATE GOVERNMENTS AND STATE POLLUTION CONTROL BOARDS	a. To take all suitable measures to prevent pollution on the shoreline. b. To render all possible assistance to the coordinator of the On Scene Commander, Local Action Group, and District Commander, particularly in accordance with the contingency plan. c. To maintain the adequate quantity of basic pollution response equipment like deflective booms, fence booms, and spray equipment along with specialized equipment for beach protection and shoreline clean-up. d. To identify a suitable type of tug/boat/fishing vessel in consultation with the On-Scene Commander/ Coast Guard for mounting the dispersant spraying equipment. e. To identify places for waste oil disposal/ pits. f. To take actions as applicable to the major ports, in respect of incidents at ports under jurisdiction.
MERCANTILE MARINE DEPARTMENT	a. To assist the coordinator of the local contingency plan if requested. b. To provide technical advice to local groups if requested. c. To identify surface craft to assist the Coast Guard with pollution response if requested. d. To assist the Coast Guard if requested or instructed by DG Shipping to examine ships for efficiency of anti-pollution equipment as per the provision of the Merchant Shipping Act, 1958.

LOCAL FISHERIES AUTHORITY	a. To assist/advise Local Groups in identifying the rich fishing grounds so as to give priority to the protection of such grounds from oil spills as well as the use of dispersants. b. The local action groups in consultation with Coast Guard regional headquarters to identify the fishing vessels suitable for mounting the oil spill dispersant equipment
COASTAL OIL REFINERIES AND CRUDE OIL TERMINALS	a. To assist the local action group in the implementation of the Local Action Plan. b. To assist the local action group in obtaining from their headquarters available additional equipment and chemicals if and when required. c. To assist in chartering of tankers to undertake transportation/transhipment operations. d. To arrange for the storage of oil transhipped. e. To assess the value of oil transhipped and the cost of refining or disposal as the case may be.
OFFSHORE OIL INSTALLATIONS	a. Occupiers of offshore oil installations are to maintain an oil spill contingency plan meeting specified requirements and maintain appropriate manpower, equipment, and resources for oil spill response taking into consideration any guidelines and suggestions that may be issued by the Government of India/ Coast Guard from time to time. b. To periodically forward a list of response inventory to the Coast Guard for scrutiny, evaluation, and updating holdings. c. To provide response equipment, material, trained personnel, and ships when required by the Coast Guard/ OSC on an available basis and without affecting the safety of operations. d. To immediately combat oil pollution around its installations up to 500 meters and continue to provide equipment, material, trained manpower, sampling efforts, and vessels as

	may be required by OSC when such oil spill spreads beyond 500 meters. e. To provide data on crude oil and oil discharges. f. To provide data on sub-sea pipelines as required by OSC MRC or CG MRCC. g. To provide transhipment facilities in case the offshore installation or any agency under its control is the polluter. h. To provide staging facilities for helicopters in the offshore areas when engaged in pollution response in the vicinity whether or not the installation and agencies under its control are the polluters.
OFFSHORE OIL INSTALLATIONS	a. Occupiers of offshore oil installations are to maintain an oil spill contingency plan meeting specified requirements and maintain appropriate manpower, equipment, and resources for oil spill response taking into consideration any guidelines and suggestions that may be issued by the Government of India/ Coast Guard from time to time. b. To periodically forward a list of response inventory to the Coast Guard for scrutiny, evaluation, and updating holdings. c. To provide response equipment, material, trained personnel, and ships when required by the Coast Guard/ OSC on an available basis and without affecting the safety of operations. d. To immediately combat oil pollution around its installations up to 500 meters and continue to provide equipment, material, trained manpower, sampling efforts, and vessels as may be required by OSC when such oil spill spreads beyond 500 meters. e. To provide data on crude oil and oil discharges. f. To provide data on sub-sea pipelines as required by OSC MRC or CG MRCC. g. To provide transhipment facilities in case the offshore installation or any agency under its control is the polluter.

	h. To provide staging facilities for helicopters in the offshore areas when engaged in pollution response in the vicinity whether or not the installation and agencies under its control are the polluters.
RECEIVER OF WRECKS	a. To assist Local Action Groups in whatever manner necessary and possible. b. To take all actions necessary under Part XIII of the Merchant Shipping Act, 1958 (In this connection, the receiver of wreck shall consult the DGS, as and when required). c. In situations where he has the local responsibility for certain actions and/ or operations, he may authorize other agencies, who are better equipped.
BOMBAY NATURAL HISTORY SOCIETY	a. Advise in restoration and cleaning of affected wildlife. b. Assist in estimating affected birds, and mangroves in the area. c. Identifying, monitoring, and mitigating the adverse impact of oil spills on the bio-diversity. d. Identifying Important Bird Areas (IBA). e. Environmental Information System (ENVIS) Centre to study Avian Ecology. f. Ecological Benchmarking in association with corporations, government, and other NGOs.
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE	a. Assist in estimating the effect of the spill on fish and the livelihood of fishermen in the area. b. Assist in identifying the types of fish in the area. c. Assist in the restoration of fishing in the area after clean-up. d. Assist in estimating the Economic loss due to the ban on fishing in the affected area. e. To understand the fluctuations in abundance of marine fisheries resources in relation to changes in the environment.

	f. To develop suitable mariculture technologies for finfish, shellfish, and other culturable organisms in open seas to supplement capture fishery production. g. To act as a repository of information on marine fishery resources with a systematic database. h. To provide consultancy services.
INTEGRATED COASTAL AND MARINE AREA MANAGEMENT PROJECT DIRECTORATE	a. Responsible for the preservation and conservation of the marine environment in India. b. Identify the high-risk areas. g. Promulgate the sensitivity mapping and area of priority.
MANGROVE SOCIETY OF INDIA	a. To protect and conserve Indian mangroves by adopting environment-friendly, scientifically sound techniques/methodologies. b. To build up their capacities for the protection and conservation of Indian mangroves. c. To act as a watchdog and advise in matters concerning the conservation of mangroves. d. To train younger generations and create awareness amongst them to conserve and protect mangroves. e. To organize alliances and networks with partners to develop an appropriate developmental perspective to conserve mangroves. f. To organize issue-based forums to achieve appropriate solutions to mangrove protection. g. Capacity building of port and oil agencies, central government and other state government agencies, stakeholders, etc. by providing necessary training for their personnel. h. To assist and coordinate activities pertaining to mangrove restoration consequent to oil pollution.

	i. To play an active role in ensuring the participation of local people in making decisions in respect of mangroves. j. To provide necessary scientific information in respect of mangroves
NATIONAL BIODIVERSITY AUTHORITY	a. To regulate and advise the Government of India on issues of conservation, sustainable use of biological resources, and fair and equitable sharing of benefits arising out of the use of biological resources. b. To advise the Central Government agencies on matters relating to the conservation of biodiversity, sustainable use of its components, and equitable sharing of benefits arising out of the utilization of biological resources; and advise the State Governments in the selection of areas of biodiversity importance to be notified under Sub-Section (1) of Section 37 as heritage sites and measures for the management of such heritage sites. c. The State Biodiversity Boards (SBBs) are to advise the State Governments, on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources. d. The local level Biodiversity Management Committees (BMCs) are to promote conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity

REEF WATCH MARINE CONSERVATION	a. To conduct education, awareness, training and capacity-building programs for stakeholders. b. To provide expertise through its Information Network of institutions and individuals working on marine and coastal issues for the development of OSCPs and incident response. c. To provide environmental information/education on biodiversity hotspots. d. To provide policy support. e. To facilitate dialogue and consensus at various levels for conservation, management, and sustainable utilization of coastal and marine resources/ecosystems in the development of protection priorities in OSCPs, NEBA, and incident response.
MS SWAMINATHAN RESEARCH FOUNDATION	a. To provide advice on the conservation of mangrove wetlands and sustainable utilization of their resources.
WILDLIFE TRUST OF INDIA	a. To assist in managing or preventing wildlife crises and mitigating threats to individual wild animals, their populations and habitats through holistic strategies and practical interventions. b. To maintain national database on wildlife protected area and share the data with stakeholders for development of OSCPs and incident response.

The discussion in this section and the above tables (Tables 4 and 5) show the roles and responsibilities of various agencies and special advice to combat oil pollution. Based on this available information from NODCP, 2015, the present committee framed the roles of various agencies to combat tarball pollution along the west coast of India as given below table (Table 6).

Table 6. Allocated business rules of various agencies to combat tarball pollution along the west coast of India.

AGENCIES	ROLES
STATE GOVERNMENTS	• The State and District Authorities will perform **response activities (cleaning and disposal) through authorities** such as Transport, Coastal Zone Management, Conservation and Resource Management Departments, Environmental Protection Authorities, emergency services, port/harbour authorities, and local conservation groups.
INDIAN COAST GUARD	• Provide quarterly report on offshore oil spill events/cases if any based on their regular surveillance (water/aerial).
CENTRAL POLLUTION CONTROL BOARD	• To render all possible assistance to the state government, through its state pollution control boards, particularly in accordance with the contingency plan. For example, according to the GOA-SOS-DCP-01, the GSPCB responsibilities are as follows. **Goa State Pollution Control Board (GSPCB):** To maintain a ready list Identified and approved. (i) Authorized waste management facilities /agencies (recyclers/incinerators) for safe disposal of oil-contaminated debris and oil waste in line with the relevant Legislation. (ii) The identified storage facilities at each ERC site (containers & storage enclosures)- (Temporary or otherwise) should be designed as per appropriate safety measures, that can safely store oil /oil contaminated dirt collected till safely disposed of. (iii) Authorized Hazardous waste transporter, which must submit plans to that effect in line with the Hazardous Waste (Management,

	Handling & Transboundary Movement) Rules 2008 as amended & Transboundary Movement) Rules 2008 as amended. (iv). To assist in restoration measures of the affected shoreline/coastal areas through "polluter pays" principal. (v) To coordinate with Dept of Environment, Coast Guard, and DG Shipping for issuing notice against the polluter master/owner for clean up, remediation, and recovery of monitoring cost of the total affected area.
MINISTRY OF PORTS, SHIPPING AND WATERWAYS THROUGH DG SHIPPING	• The responsibility for clean-up of pollution on the water and at jetties wharves/structures within the jurisdiction, and at beach/shoreline owned by the port authority, whatever the source of the pollution, lies with the port authority. Clean-up of shoreline (including land exposed by falling tide) beyond port jurisdiction vests with the local administration. • To take administrative and legal action for processing claims against damages incurred by the Coast Guard and other agencies relating to any other oil pollution incidents. • Advise concerned agencies to collect evidence for the purpose of claims of pollution ships.

MINISTRY OF PETROLEUM AND NATURAL GAS THROUGH ITS OFFSHORE INSTALLATIONS	• Provide detailed reports on oil pollution around each and every installation up to 500 meters for the period of 45 days from the date of tarball deposition to backward.
NATIONAL REMOTE SENSING AGENCY	• To identify the oil spill events (either ship or oil field-based) through satellite imagery in coordination with the Indian Coast Guard, if any occurred before the tarball deposition period.
THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH	• Map the risks and consequences of tarball pollution to fisheries and aquaculture. • Provide scientific advice on the effect of tarball pollution on fisheries and aquaculture. • Document the impacts of tarball on fisheries and aquaculture.

Objective 6: Standard Operating Procedures (SOPs) in alignment with the NOS-DCP for offshore oil field operators, Passenger Ships/Cargo vessels, and accidental spillage, the typical contributors to the oil-spill events in the marine environment.

6.1 Standard Operating Procedures (SOPs) for offshore oil fields

1. The respective company/organization should have a robust oil spill management system in place to address oil spills incidents ranging from minor to major. As per the National Oil Spill Disaster Contingency Plan (NOS-DCP) promulgated by the Indian Coast Guard, it is mandatory to maintain Tier-I (up to 700 tons) oil spill response equipment and manpower on-board multi-support vessels in its operational area. To handle the spills of Tier-II (700 to 10,000 tons) and Tier-III (beyond 10,000 tons) level, the combat agency will require local, regional, national possibly international assistance, facilitated by the Statutory agency through the Ministry of External Affairs.
2. Effective oil spill contingency plans and emergency response procedures should be in place to respond to oil spills if they occur. The National Oil Spill Disaster Contingency Plan (NOS-DCP) covers all incidents in any part of the sea, or inland, that is likely to affect the maritime zones of India, including Territorial Waters, Exclusive Economic Zone (EEZ) of India and the High Seas where an oil or chemical spill has the potential to impact on Indian interests.
3. Closed oil handling system, inbuilt automatic shutdown valves, Leakage Detection System (LDS), and Pipeline Intrusion Detection System (PIDS) in oil trunk pipelines at the design stage and operating procedures for all critical operations for prevention of oil spills should be maintained to curb pipeline leakages. In addition to this, a corrosion survey needs to be carried out regularly.

4. Offshore Environment Monitoring around the oil fields should be carried out seasonally every year through any NABL accredited agencies/National Research Institutes, and the report should be maintained.
5. Every offshore oil installation with risk of marine oil or chemical pollution is required to maintain a facility contingency plan approved as per NOSDCP. Therefore, preparation of Oil Spill Contingency Plan (OSCP) as laid down in NOSDCP and updating it periodically has been adequately emphasized which would in turn serve as the SOPs for dealing with oil spill incidents.

6.2 Standard Operating Procedures (SOPs) for Ships and any oil spill events

Every ship is required by MARPOL regulations to maintain a Shipboard Marine Pollution Emergency Plan (SOPEP) approved by the Flag State Administration. The Merchant Shipping (Prevention of Pollution by Oil) Rules, 2010 requires maintenance of a pollution emergency plan by Indian ships approved by the Administration or Recognized Organisation acting on its behalf.

Objective 7: Suggest Requirements and make recommendations with regard to the requirement of a corpus fund for undertaking shore cleaning activities in the affected States.

The shoreline of the west coast of India, particularly the Gujarat, Maharashtra, and Goa shorelines frequently experiences tarball washing ashore during every summer monsoon month when winds and currents are conducive for their transport to the shore. The planning, clean-up, and disposal associated with a coastal tarball event may require extensive central, state, and local coordination to effectively minimize the impacts on vegetation, natural resources, ecosystem, and recreational activities on the beach, and hence tourism.

Tarball cleaning can be performed in two ways. (i) manual tarball removal which involves the usage of hand tools such as shovels, rakes, pitchforks, and polypropylene drum liners. Manual removal is best for minimizing the volume of sand removed from the shoreline, therefore requiring less disposal. (ii) Mechanical tarball removal, which involves the use of heavy equipment such as backhoes, excavators, bulldozers, and graders. Tarballs may be loaded into end-dumps, roll-off boxes, or other methods for disposal. Care should be taken to remove as little sand/sediment as possible. Tarballs should be disposed of either through co-incineration in a cement plant or in common incineration in the Treatment, Storage, and Disposal Facility (TSDF).

In view of the above, the committee recommends that the corpus fund is needed for the cleaning and disposal of the tarball/oil residue affected sites but with a proper scientific method. The corpus fund if created should get proportional contributions to all Oil Handling Agencies (OHAs) based on the quantity of oil being handled by them. The possible stakeholders of OHAs include the Exploration and production companies operating in the Gulf of Kuchchh, Gulf of Khambat, off Mumbai and western offshore; coastal refineries operating at Jamnagar, Vadinar,

Mumbai, Mangalore, and Kochi, Major shipping companies (e.g. Shipping Corporation of India, Essar Shipping Limited, Great Ship India Limited etc.). Thus, broadly the committee recommends that the appropriate departments that can raise the corpus funds are the Ministry of Petroleum and Natural Gas; and the Ministry of Ports, Shipping, and Waterways. However, this is only the committee's suggestion. The final decision may be taken by the competent authority.

A meeting has been conducted by CSIR-NIO with ONGC (IPSHEM, Betim, Goa), GSPCB, the Goa Tourism Department, and Goa Waste Management Corporation to exclusively discuss the topic. The outcome of the meeting was to estimate the total cost involved from cleaning, transportation, and disposal and the disposal method. The following template is made accordingly for the estimation of the cost involved, which may slightly change from state to state based on the local rates. The following table (Table. 6) is the rough estimation of the tarball cleaning at Goa coast beaches for six months (April to September) of any one tarball deposition year. Accordingly, for the other two states Maharashtra and Gujarat coasts also can be worked out based on their local cost of cleaning, transportation, and disposal expenditure.

Table 7. Template for the cost estimation for the cleaning, and disposal of tarball at the Goa shoreline.

Expense Category	**Description of expenses involved**	**Cost Estimation at each coastal sate (in Lakhs)**
Collection Equipment	- Boats and vessels for tarball collection - Nets, scoops, and other collection tools - Personal protective equipment for collectors	**2**

Storage Facilities	- Storage tanks or containers for collected tarballs - Security measures for the storage area - Maintenance and monitoring of storage facilities	**3**
Transportation	- Transport vehicles for moving tarballs - Fuel and maintenance for transport vehicles - Packaging materials for safe transportation	**5**
Disposal Methods	- Treatment and processing of collected tarballs - Disposal through incineration -	**50 (up to 100 metric ton quantity of tarball)**
Labor Costs	- Personnel salaries for collection, transport, etc - Overtime and additional labor-related expenses	**2**
Training and Education	- Training programs for proper tarball handling - Workshops on safety and environmental guidelines	**1**
Monitoring and Compliance	- Regular inspections and monitoring of collection and storage area - Compliance with regulations and reporting	**2**
Miscellaneous	- Contingency budget for unforeseen expenses - Communication and outreach efforts	**2**
Total Expenditure		**67**

The Goa State Pollution Control Board (GSPCB) recommends that additional may be retained in case of emergency of oil spill to be subsequently reimbursed by polluter pay Principal.

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Annexure – A

1. Experimental Section

1.1 Sample Collection

Tarball samples were collected by Gujarat Pollution Control Board from the beaches of the south Gujarat coast such as Nargaol (NB1, NB2) and Umbergaon (UB1, UB2) on 15 July 2012 and Maroli (MB1, MB2), Tithal (TB1, TB2), Nargaol (NB3, NB4) and Umbergaon (UB3, UB4) on 17 July 2012 whereas on the Goa coast, CSIR-NIO collected the samples all the years. Samples were collected and kept in glass bottles and stored in the laboratory refrigerator before the analysis. Similalrly tarball samples along the beaches of Goa were collected by CSIR-NIO. We also collected crude oil samples as detailed here: (i) two BH-based crude oils. BH oil fields are located ≈ 250 km away from the sampling points (Gujarat coast). The crude oil produced from various platforms of BH reaches the Uran plant through two main pipelines a 30" MUT (Mumbai High Uran Trunk) oil pipeline from the BH and a 24" HUT (Heera Uran Trunk) oil pipeline from the Heera offshore Platform; (ii) two crude oil samples produced off Gujarat coast, and operated by the Cairn and Niko firms and (iii) one crude oil sample collected from the vessel MSC Chitra (MSC) during its grounding (after collision with MV Khalijia-III on 07 Aug 2010, off Mumbai coast).

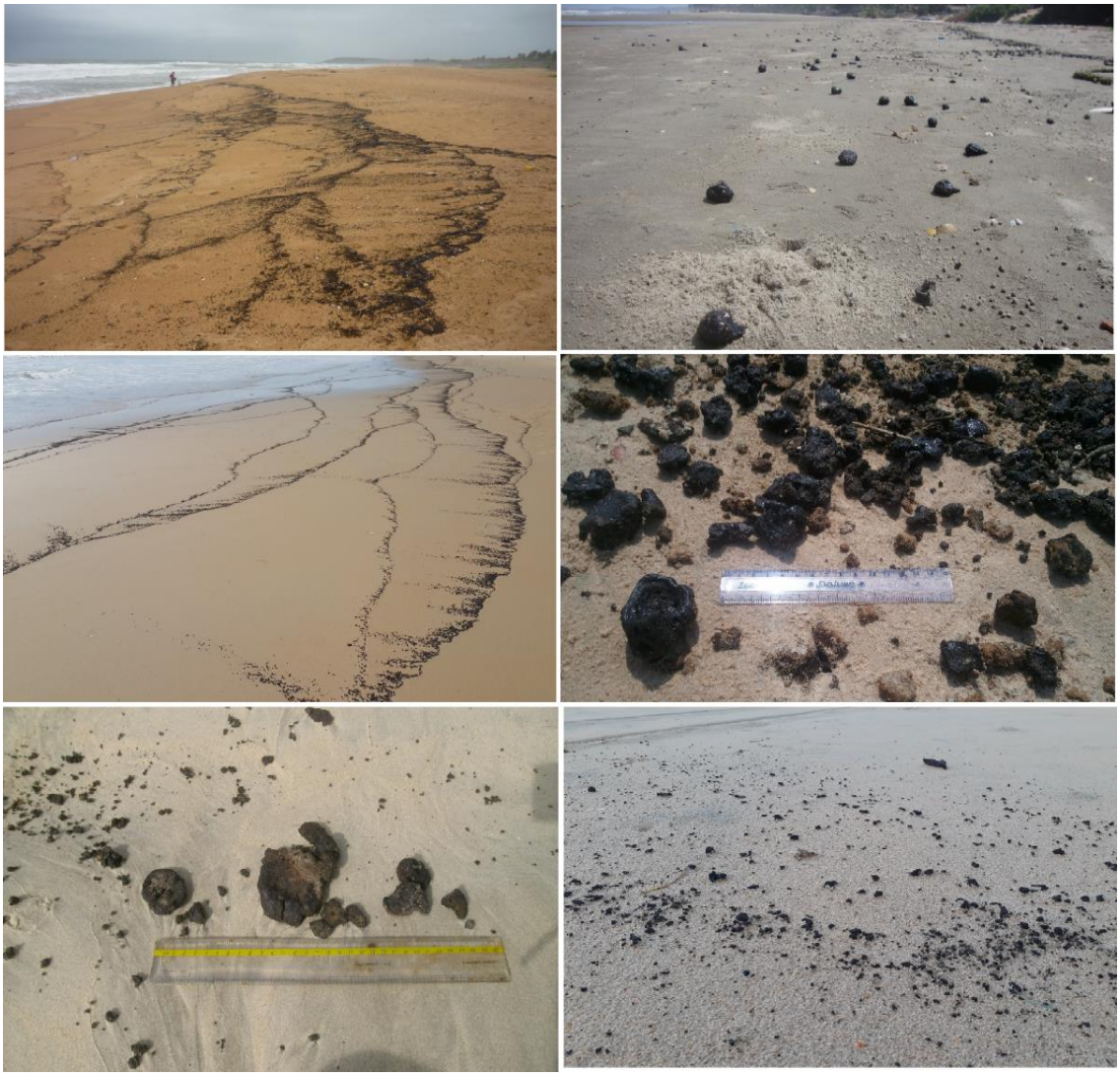


Figure 11. Illustration of various types of TB deposits on the beaches of Goa: (a) Candolim, August 2010, (b) Mandrem, May 2011, (c) Mobor, May 2012 and (d) Candolim, Jun 2014, (e) Colva, 2015 and (f) Mobor, 2016.

1.2 Extraction and Chemicals

Crude oil and TB samples weighed precisely 20 mg and 30 mg, respectively. Detailed analytical processes and fractionations are given in Suneel et al. (2013, 2015, 2015). Authentic standards for alkanes and PAH (Sigma Aldrich, USA) and hopane standards 17β (H) 21α (H)-hopane (C_{30}17βα), 17α (H) - 22, 29, 30- trisnorhopane (Tm) (Chiron, Norway) were used. Crude oil and tar ball samples weighed precisely (130 mg) and dissolved in 50 ml of n-hexane. Picked 10 ml of solution (which contains

the raw sample weight of (26 mg) and transferred to 5% H2O deactivated silica gel column (1cm i.dx 9cm). Hydrocarbons ranging from alkanes to PAH were eluted with 25 mL of DCM/hexane (1:3 v/v); 5 gm of activated copper was added to the collected elute and allowed to stand overnight to react with sulphur. Then the copper was removed and the sample was subjected to roto-evaporation to decrease the volume to 2 mL. The sample was then transferred to the fully activated silica gel column (0.47cm i.d x 18 cm). Two fractions were eluted. The first fraction (F1) was eluted with 10 mL of hexane containing the aliphatic and alicyclic hydrocarbons (Aliphatic hydrocarbon fraction). The second fraction (F2) was eluted with 20 mL of hexane/DCM (3:1, v/v) containing the higher molecular weight PAHs (Aromatic Fraction). These two fractions were evaporated to dryness under the nitrogen blowdown, rinsed with DCM HPLC grade, transferred to 1.5 mL ampoule, and added with 200 µL isooctane for further GC-MS analysis. All samples of F1 are used for analysis of the total saturates, n-alkanes and isoprenoids, and biomarker compounds; and F2 is used for analysis of alkylated PAH homologues and other EPA priority parent PAHs, and aromatic steranes.

1.3 Gas Chromatography-Mass spectroscopy (GC-MS) analysis

Analyses for *n*-alkane, sterane and hopanes for TBs and crude oil samples were performed using a two dimensional Shimadzu QP-2010 Gas Chromatograph and Mass Spectrometer interfaced with an AOC-20i autosampler. Using Helium as the carrier gas, a fused silica capillary column RXi-5 of RESTEK 30m × 0.25mm id (0.25 µm film thickness) was used in GC-MS. The injector and detector temperatures were set to 280°C and 220°C, respectively. The oven temperature program was: 1 min hold at 40°C; ramp to 10°C at 140°C/min; and ramp to 320°C at 6°C/min and finally a 15 min

hold at 320°C. Analyses for EPA-16PAH were performed using the same GC-MS with a fused silica capillary column RXi-5 of RESTEK 60m × 0.25mm id (0.25 µm film thickness). The injector and detector temperatures were set to 220°C. The oven temperature program was 2 min hold at 70°C; ramp to 30°C at 150°C/min; ramp to 4°C at 310°C/min and finally a 0.33 min hold at 310°C. The consistency of the GC-MS was checked with 5 runs of n-alkane standard (C_8-C_{40} n-alkane). All the runs are consistent with each other.

1.4 Gas Chromatography-Isotope Ratio Mass Spectroscopy (GC-IRMS)

Carbon isotopic ratios of individual n-alkanes have been determined on Agilent 7890 A GC-C-IRMS coupled with Agilent 7000 GC-MS triple quad interfaced with oxidation-reduction reactor (980-650^{o}C). The GC was equipped with an HP-5 MS column (30m X 0.25mm inner diameter with 0.25 µm film thickness). The oven temperature program was: 1 min hold at 70^{o}C; ramp to 140^{o}C at 10^{o}C/min; again ramp to 300^{o}C at 6^{o}C /min and finally a 30 min hold at 310^{o}C with helium as the carrier gas. Initially, the instrument was calibrated using the A5-mix NIST standards. The reproducibility of the results was checked with triplicate analysis of A5 mix standards containing 15 n-alkane compounds and C3 mix standards containing 5 n-alkane compounds. The standard deviations are in the range of 0.18-0.26(‰) for A5 and 0.05-0.06 for C3 standards. Results were reported in the standard delta notation as per mil (‰) deviations from the VPDB (Vienna ***pee Dee belemnite***).

1.5 *Modelling Hydrodynamics and Particle Tracking*

Winds and currents are the major forces that are responsible for the transport of tarball particles to the coast. Therefore, we have relied on atmospheric and ocean

models to obtain these parameters for each grid point in the model domain. A short description of the models used in this study is given below. The oil residue or a tall ball advects along with surface winds and currents, and their net movement can be simulated using a tracking method. Currents for the selected domain have been simulated using the MIKE21 hydrodynamic model. MIKE21 HD Flow model is a hydrodynamic modelling system for 2D free surface flows. It is widely used for the simulation of currents, water level variations, sediment transport, and particle tracking in estuaries and coastal areas. MIKE21 can accommodate a high-resolution grid for the simulation of water level variations, currents, and all other related parameters. It solves 2D shallow water equations of momentum and continuity equations in a vertically integrated and incompressible mode. The vertical acceleration of the flow is assumed much smaller than the pressure gradient. The bathymetry data are generated from the combined data of MIKE-CMAP and modified ETOPO 5 (Sindhu et al., 2007). The water levels were predicted for open boundaries from the Global Tidal Model (built-in MIKE ZERO).

1.6 Practical tracking model

Tarball transport is tracked using the Particle Analysis (PA) module of MIKE 21. PA module is based on the Lagrangian Random walk technique, and is used for the simulation of trajectory of tarball; tarballs are considered as floating passive particles. The input parameters required to run the PA are winds and currents. In the present study, currents are obtained from the MIKE 21HD and winds from the WRF model. Using these inputs, we have run the Particle Analysis model for the period August 2010.

1.7 *Backtracking numerical model*

Backwards-in-time tracking or reversed trajectory method combines the use of sequences of realistic meteorological and oceanographic data with the 'receptor mode' technique (Galt and Payton, 1983), where lagrangian particles are tracked backwards in time from a receptor site to multiple possible sources offshore. In this study, the backward-in-time method has been used with a reanalysis of wind and current data to simulate a single tarball deposition scenario for a period of 1-2 months. The Lagrangian particles (tarballs) have been seeded in multiple starting points (receptor sites) near the coast of Goa along the 10m isobath and uniformly released for 1-2 days, corresponding to the observed beaching period. Trajectories of the 2013 and 2014 events are depicted in the report section 1.1.2. About 50,000 particles have been released for each run. In these simulations, the movement and spreading of the particles are controlled by wind drift, current advection, spreading, or diffusion, and the latter is simulated by random walk. Using the linear form of the transport equation adopted by Isobe et al. (2009) the backward trajectory of a single particle results as follows:

$$X^{t-\Delta t} = X^{t} - U\Delta t + R\sqrt{2k_h \Delta t} \qquad \text{----------} \quad (1)$$

where X^t is the position of the lagrangian particle at time t, Δt =5 minutes is the time step, U is the sum of wind drift (3% of the wind speed) and current advection (100% of the surface current), k_h = 5 m^2/s is the diffusivity of the particles and R represents a random number generated at each time step with an average and standard deviation of 0.0 and 1.0, respectively. Wind data from the ECMWF have been updated every 6 hours; current data extracted from the OSCAR datasets at a spatial resolution of 1/3°

have been updated at 5-day intervals. Wind and current data were loaded in the reverse order, i.e. starting from the oldest one, and have been linearly interpolated in time and space before being used in Eq. (1).

1.8 Remote sensing satellite data acquisition

This study makes use of the satellites Sentinel-1A and Sentinel-2 (A and B) images obtained from the European Space Agency's (ESA's) Sentinel Scientific data hub and Earth Data Alaska Satellite Facility (ASF) (https://search.asf.alaska.edu/#/). The satellite Sentinel-1A was launched on 03 April 2014, and Sentinel-2A- 2A and 2B were launched on 23 June 2015 and 07 March 2017, respectively, by the ESA. Sentinel-1 carries the C-band Synthetic Aperture Radar (SAR) with a frequency of 5.405 GHz and a wavelength of 5.5 cm. The acquired images are of Ground Range Detected (GRDH) products with a sensor mode of Interferometric Wide (IW) swath having 250 km spatial coverage and 10 m × 10 m high pixel resolution. We chose to use only IW mode out of the four available sensor modes (IW, Strip map (SM), Extra-Wide swath (EW), and Wave mode (WV)), as it is the best suitable mode for oil spill detection (Conceiç˜ao et al., 2021, Torres et al., 2012).

Similarly, the Sentinel-1 imagery is also available in several dual-polarization bands, which are amplitude_VH, intensity_VH, amplitude_VV, and intensity_VV. However, vertical (VV) polarization is most suitable compared to horizontal (HH) polarization (Conceiç˜ao et al., 2021; Nezhad et al., 2018). Figure. 2 illustrates the VH and VV polarization of a randomly chosen sentinel-1 image. The oil spill signature is not evident in the VH polarized image (Figures 2a and b), but the spill is seen in VV polarization (Figures. 2c and d), indicating that VV polarization is best suitable for the oil spill detection in supporting with the previous studies (Conceiç˜ao et al., 2021,

Weiß et al., 2020, Prastyani and Basith, 2018, Nezhad et al., 2018). Therefore, all the sentinel images used in this study are VV polarized.

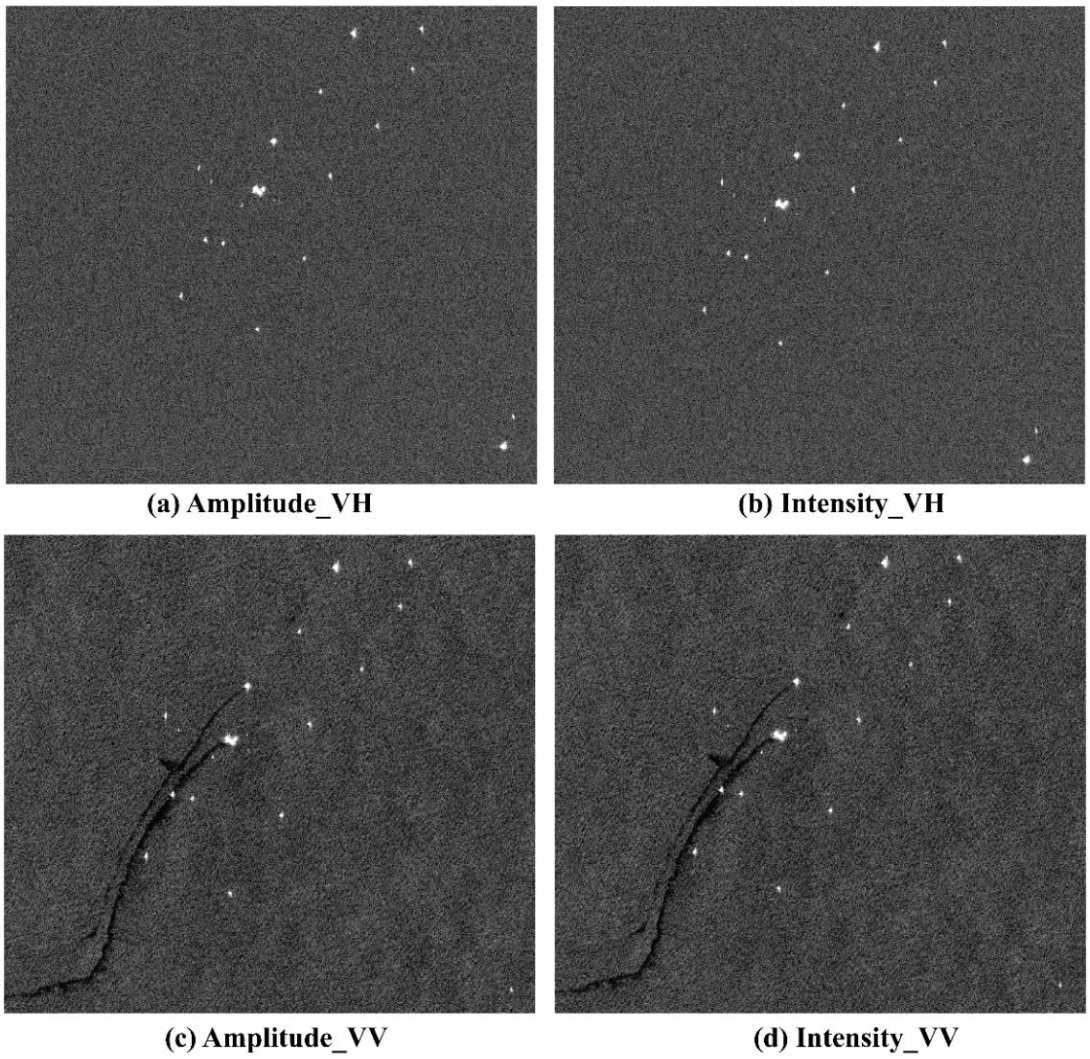


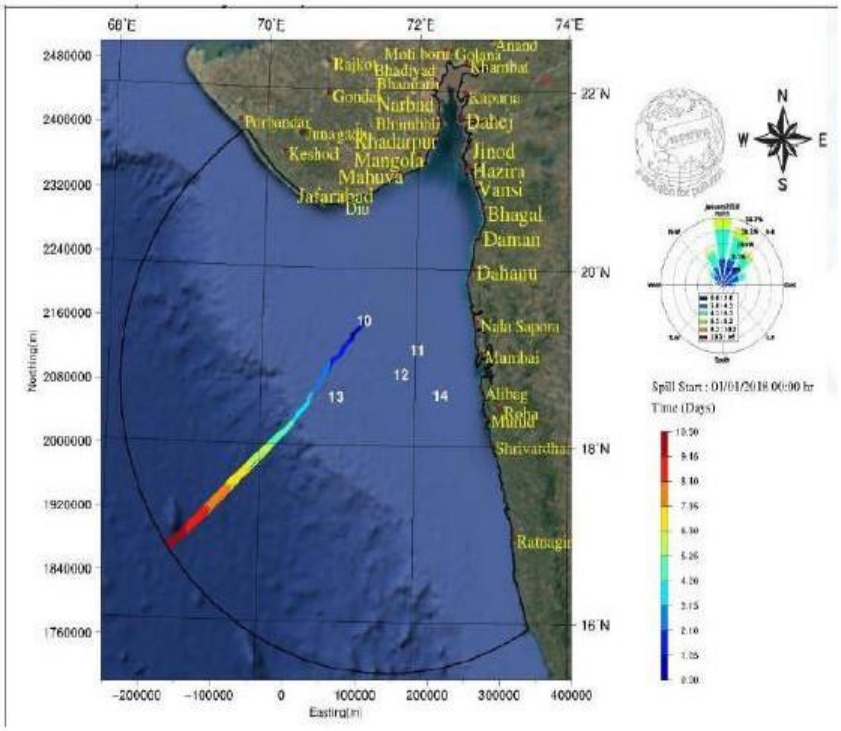
Figure 2. Different types of dual polarization bands

Annexure – B

The following oil spill modeling analysis is conducted and provided by the ONGC.

Pre-monsoon (January)

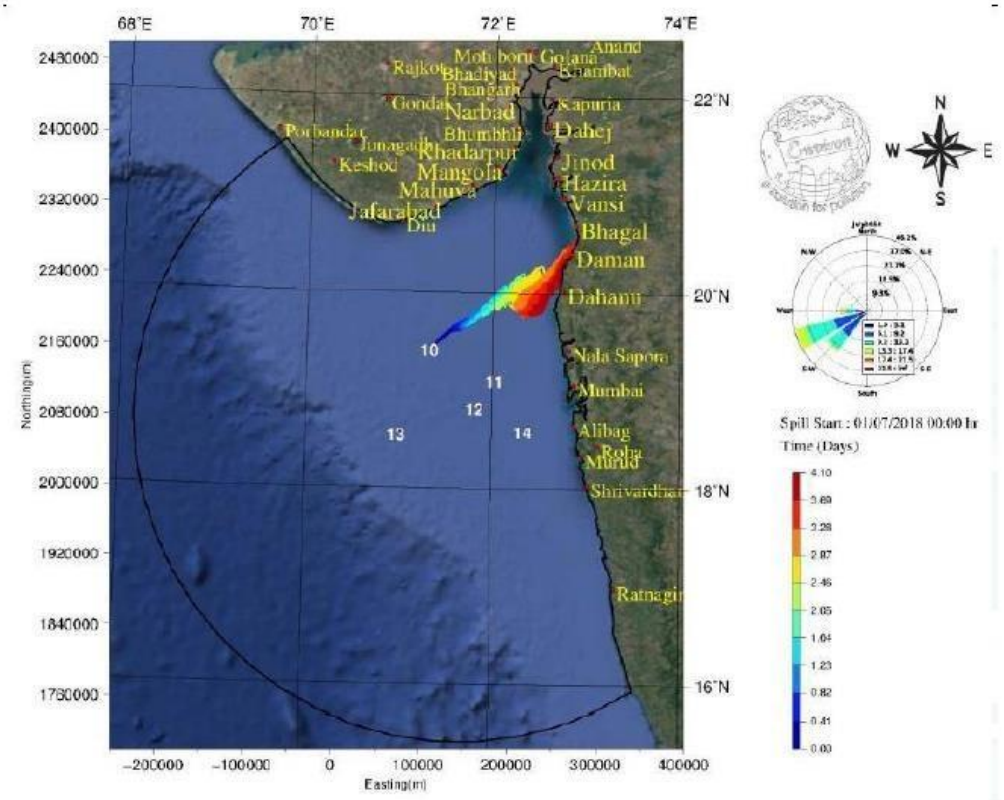
During Pre-monsoon, the tidal conditions i.e. spring and neap tides have been selected to study the trajectory of spills at 5 locations off Mumbai. The spill start time has been selected respectively early in pre-monsoon season. The simulation runs were continued for various spill of instantaneous and continuous quantities at various ONGC facilities (Fig.1.1) in west coast for 30 days continuously and spill residence time, trajectory of spills is shown below for pre-monsoon (January 2018). The following Tables gives the brief description of the oil spill results graphically for the pre-monsoon period



Pre-Monsoon (Jan) – Oil Spill Trajectory due to instantaneous oil spill of 7000m3 in MH field

Monsoon (July)

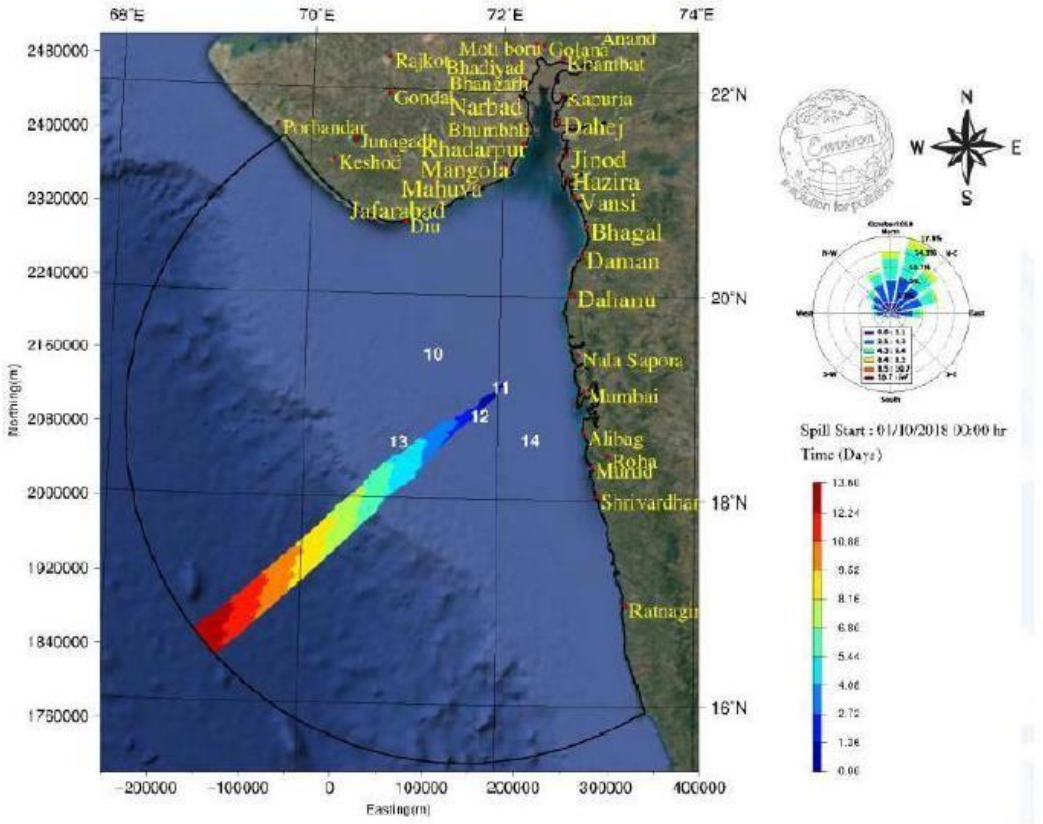
During Monsoon, the tidal conditions i.e. spring and neap tides have been selected to study the trajectory of spills (Fig.1) at 5 locations off Mumbai. The spill start time has been selected respectively early in monsoon season. The simulation runs were continued for various spill of instantaneous and continuous quantities at various ONGC facilities in west coast for 30 days continuously and spill residence time, trajectory of spills is shown below for monsoon (July 2018). The following Tables gives the brief description of the oil spill results graphically for the monsoon period



Monsoon (July) – Oil Spill Trajectory due to Continuous crude oil spill of 60m3/Hour in MH field

Post-monsoon (October)

During Post-monsoon, the tidal conditions i.e. spring and neap tides have been selected to study the trajectory of spills (Fig.1) at 5 locations off Mumbai. The spill start time has been selected respectively early in post-monsoon season. The simulation runs were continued for various spill of instantaneous and continuous quantities at various ONGC facilities in west coast for 30 days continuously and spill residence time, trajectory of spills is shown below for monsoon (October 2018). The following Tables give the brief description of the oil spill results graphically for the monsoon period



Post-Monsoon (July) Oil Spill Trajectory due to Continuous oil spill of 60m3/Hour in B&S field

Deliberations of the 2nd meeting of the Technical Sub-Committee created to assist the Joint Committee constituted by the Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to the formation of Tar-balls along the coast of Goa, Gujarat, and Maharashtra

The 2nd meeting of the above referred Technical Sub-Committee was held on 07-Nov-2023 chaired by Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC. The detailed list of participants is annexed in Annex-I.

2. At the outset, the MoEFCC representatives welcomed all the participants and provided a background of the issue, which is annexed in Annex II. The MoEFCC, on the recommendation of TSC, had awarded a study to CSIR-NIO with specific Terms of Reference. Thereafter, the CSIR-NIO representatives were requested to make a presentation before the TSC on the findings of the report. In line with the TORs given, the NIO team started with a brief background on formation, movement, deposition, tracking of tar balls, etc. The NIO team made a TOR-wise presentation, and the Committee made observations and detailed deliberations on the TORs. The TOR-wise deliberations are presented in Annex II.

3. The summary of report and observations made thereupon are as follows:

ToR Point 1 – Identification of various sources of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.	Observations • **Standard scientific techniques viz. fingerprint analysis, particle tracking or trajectory simulation, and remote sensing utilized for source identification** • East Arabian Sea has three oil spill/ slick hot spot zones i.e. near the Gulf of Kutch (Gujarat), Off the Mumbai coast (near Bombay High Oil fields), and off the Karnataka-Kerala coast • Tar ball occurrences in Gujarat in April, and Goa between May to September are indicative of the influence of wind, local tides, surface currents, and the south-westerly monsoon system. • **The intensity of events along the timeline indicates that offshore operations in the Bombay High Oil Fields are the major sources of the oil spill and slicks, followed by the movement of ships (passenger and cargo)**
ToR Point 2 – Review the current mechanism	Observations

of addressing tar-ball problem at Indian coasts/ beaches and identification of gaps	• Tar ball management is done by the State Government/ District covering their manual or semi-mechanical collection and transportation to Authorized TSDF • **'Polluter pays Principle' needs to be introduced** • ONGC recommended the usage of porphyrin compounds chelated with metals for tar ball tracing • Ascertaining nature and source of oil spills is challenging, and may include operational mismanagement in oil fields, pipeline leaks, or natural seepage. • Need for coordination and communication among government agencies, and stakeholders (oil field operators and ship operators) • Strengthening of requisite infrastructure for tar ball cleanup on 'Polluter pays Principle' • Need for public awareness, enforcement of environmental regulations, and adequate reporting mechanisms to initiate actions in a timely manner
ToR Point 3 – Suggest preventive measures required at source in respect of all scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc. to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls	Observations • **Detailed list of preventive measures provided in study report w.r.t. oil field operations, movement of ships, and oil spill events**. • Manual methods such as a hand rake and shovel, sorbents, or mechanical methods such as maintainers/ road graders and small front-end loaders, skimmers, and vacuum systems can be used to remove oil deposited on a surface
ToR Point no.4 – Study of global best practices on prevention of tar balls formation and measures taken to contain tar ball pollution –	Observations • Globally, tar balls management is addressed through various measures like Oil Spill Cleanup Plans and Expert Teams, **implementation of regulations, globally coordinated actions[1] (by IMO, OPRC, and MARPOL)**, contingency plans and EIA, spill response equipment and training, improved tanker designs, use of oil spill dispersants, monitoring and research, and suspended oil detection methods

	• Further, sensitivity assessment is done considering the presence of natural resources such as birds, shellfish, drinking water intakes, corals, and coastal recreational areas in a geographical region • Advanced technologies, such as remotely operated vehicles (ROV) and automated underwater vehicles (AUV) may be utilized for the detection and management of underwater oil plumes during spill events
ToR Point no.5 – Suggest viable mechanisms to arrest tar-balls at Sea, based on global practices	Observations • Since tar ball pollution is caused by the oil spills or oil slicks, its management strategy must focus on the prevention of oil spills, and arresting the oil spill • **No feasible mechanisms are available to arrest tar ball at high seas** • Oil spills and tar ball pollution at sea (near shore) can be contained with the help of shore sealing booms, aerial surveillance and response, and Bioremediation
ToR Point no.6 – Suggest introducing administrative and technical frameworks for monitoring/ under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies	Observations • Indian Coast Guard (ICG), Ministry of Defence is the central coordinating authority for combating oil spills in Indian waters as per the Government of India (Allocation of Business) Rules, 1961, and has developed a National Oil Spill Disaster Contingency Plan (NOS-DCP) outlining functional responsibilities for various Ministries and Departments of the Government of India, the State Governments and the District Administration in responding to oil spills in Indian maritime zones. • Recommendations considered for further delegation of certain responsibilities in line with NOS-DCP • Provisions of OPRC and MARPOL can be effectively utilized in oil spill management and tar ball formation
ToR Point no.7 – Prepare detailed Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger	Observations • Study report has enlisted Standard Operating Procedures (SOPs) for Offshore Oil fields, Movement of Ships, and other oil spill events that are aligned to the NOS-DCP • Adequate guidance and regulations are also

Ships/ Cargo Vessels, Oil Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOSDCP)	available under the OPRC and MARPOL conventions to prevent and manage oil spill incidents • Concerned agencies are required to synergize while implementing the provisions • Three response mechanisms viz. Mechanical containment or recovery, Chemical and biological methods, and Physical methods are mentioned
ToR Point no.8 – Suggest requirement and make recommendations with regard to the requirement of a corpus fund for undertaking shore cleaning up activities in the affected states	Observations • In view of the non-feasibility of arresting tar balls on high seas, the focus should be to collect, arrest, and manage tar balls near the shore and along the coast. • Tar ball removal may be done by manual and mechanical methods, and disposal may be done through co-incineration in a cement plant or common incineration in the Treatment, Storage, and Disposal Facility (TSDF). • Based on Polluter pays principle, a mechanism to finance shore cleaning-up activities may be developed with the involvement of industries/ stakeholders engaged in Offshore crude oil production, Oil transport pipeline infrastructure, Coastal Refineries, Ports, Harbors, and Jetties, Wharves and other shipping infrastructures, Coastal oil receiving facility operators, and Ships transiting through the hotspot zones identified in the study report

4. After detailed deliberations, the TSC made following recommendations:

i. **It is inferred from the report that the main sources of the oil and resulting tar balls are offshore oil rigs/ drilling operations, to a major extent, and shipping lines/ tankers to some extent.**
ii. **NOS-DCP may be updated to include new and advanced measures like ROVs and AUVs, to detect and manage underwater oil plumes during spill events to effectively tackle the oil spill incidents, which eventually result in the formation of tar balls. Additionally, the responsibilities assigned to key stakeholders are synergized with the provisions stipulated under MARPOL and OPRC.**
iii. **Coastal State Governments, through the involvement of the State Environment Department and State Coastal Management Authority, should constitute a State Level Crisis Management**

Group for the management of oil pollution incidents and tarball pollution, and direct the local administration (or authorities) to set up a District Shoreline Response Centers (DSRC)

iv. **CPCB to develop a Standard Operating Procedure for the utilization of Tar Balls in the cement industry through co-processing or any other waste-to-energy method, and its disposal in the TSDF**

v. **CSIR-NIO (M/o Science and Technology), NIOT (M/o Earth Sciences), INCOIS (M/o Earth Sciences), NCSCM (M/o Environment, Forest and Climate Change) and CPCB may form a consortium and develop an Environmental Sensitivity Index of various coastal areas considering the presence of natural resources, such as birds, shellfish, drinking water intakes, corals, and coastal recreational areas in the geographical region. CPCB may coordinate this activity.**

vi. **State Governments may undertake the compilation of time-series data of oil spills and tar ball formation events and tie up with R&D institutes to develop mathematical models to make advanced predictions, and preparations, and have better decision-making.**

vii. **MoPNG and M/o Ports, Shipping and Waterways (M/o PSW) to undertake consultation with key stakeholders identified in ToR point no.8. and create a corpus fund for financing the activities of District Shore Cleaning Centers, including purchase and maintenance of equipment for shore cleaning, transport of tarball waste from shore to disposal facility or industry, undertake further research in oil spill and tarball pollution, and other associated expenditures related to the management of oil spill and tarball pollution. MoPNG will also develop a mechanism of continuous monitoring and implementation of the above recommendations, and all prevention and mitigation measures.**

viii. **MoPSW and the Directorate General of Shipping may ensure that the guidance, regulations, and Standard Operating Procedures provided under the OPRC and MARPOL convention are implemented rigorously.**

5 . The Chair, while summing up the deliberations, informed that the observations and the recommendations of this TSC shall be placed before the NGT-constituted Joint Committee Co-chaired by by the Secretary (EF&CC) and Secretary (PNG) for consideration and approval. The recommendations, thus finalized, shall be submitted to the Hon'ble NGT. Gist of the NIO report and detailed deliberations on that are annexed below for kind reference.

The meeting ended with a vote of thanks to the Chair.

Annex-I

List of Participants

1. Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC
2. Shri Ved Prakash Mishra, Director, MoEFCC
3. Shri Dinabandhu Gouda, CPCB

4. Shri Surendra Kumar Karwasara, Indian Coast Guard
5. Dr. Suneel Vasimalla, National Institute of Oceanography (CSIR-NIO), Goa
6. Shri Durbar Ray, CSIR-NIO, Goa
7. Dr Prince Prakash Jeba Kumar, National Institute of Ocean Technology, M/o Earth Sciences
8. Shri J Sethil, Director of General of Shipping
9. Shri RB Trivedi, Gujarat Pollution Control Board (GPCB)
10. Shri D.P. Patel, GPCB
11. Shri G.L. Das, DGH, MoPNG
12. Shri Gopal Bansal, DGH, MoPNG
13. Shri R Ranjan, DGH
14. Shri Subhyant Das Gupta, MoPNG
15. Shri V.C. Chaudhary, MoPNG
16. Shri Dinesh Runiwal, Scientist-E, MoEFCC

Annex-II

Gist of the report and deliberations thereupon

Background of the Issue

The Hon'ble NGT is hearing a matter related to the formation of tar ball along the western coast of India, especially in the states of Gujarat, Goa and Maharashtra. As per the directions, MoEFCC had created a Joint committee to delve upon the issue and give recommendations. The Joint Committee met on 12-April-2022 and deliberated on the issue, and considering the technical nature of the subject requiring specific domain expertise, decided to create a TSC. The TSC, created by MoEFCC, met on 10-May-2022 and undertook detailed deliberations wherein it agreed on the following:

- There is no method available to track, quantify and control crude oil seepage and slicks of natural origin
- Tar ball formations resulting from anthropogenic sources can occur due to offshore oil exploration activities, oil tanker accidents, oil-well blowouts, and pipeline leakages, release of bilge and industrial effluent from ships and tanker washes / leakage spills along tanker route.
- Considering the busy international shipping route along the west coast, it is very difficult to attribute a single source for tar ball formations with high degree of confidence
- The problem of tar-ball formation is a global issue and many countries are grappling with the problem due to location of oil fields, international shipping routes etc.
- In view of the uncertainty associated with tar ball source identification, it

would be an appropriate strategy to prepare scenario-specific Standard Operating Procedures for stakeholders

2. Further, the TSC decided to award a study to CSIR-NIO as lead agency and CPCB and MoPNG as co-lead with the following Terms of Reference:

- Identification of various sources of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.
- Review the current mechanism of addressing tar-ball problem at Indian coasts/ beaches and identification of gaps
- Suggest preventive measures required at source in respect of all scenarios like
- operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc. to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls
- Study of global best practices on prevention of tar balls formation and measures taken to contain tar ball pollution
- Suggest viable mechanisms to arrest tar-balls at Sea, based on global practices
- Suggest introducing administrative and technical frameworks for monitoring/ under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies
- Prepare detailed Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger Ships/ Cargo Vessels, Oil Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOSDCP)
- Suggest requirement and make recommendations with regard to the requirement of a corpus fund for undertaking shore cleaning up activities in the affected states.

ToR-wise deliberations

a. *Point no.1 - Identification of various sources of tar balls covering all possible scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc.*

The NIO representatives mentioned that for source identification, it has referred to various scientific studies carried out in the past (from 2009 onwards), which had employed three scientific techniques *viz.* fingerprint analysis, particle tracking or trajectory simulation and remote sensing. The Committee noted that there are three hot spot zones of oil spill in the East Arabian Sea which result in the formation of tarballs i.e. near Gulf of Kutch (Gujarat), Off Mumbai coast (near Bombay High Oil fields) and off Karnataka-Kerala coast. The nature and distribution of oil spills observed through remote sensing near Gulf of Kutch (Gujarat) and off Karnataka-Kerala coast is scattered in a linear manner around the international oil tanker route indicating the source of spills as cargo movements; however, the distribution of spill Off Mumbai coast (near Bombay High Oil fields) is concentrated around the Bombay High Oil fields.

The NIO team also referred to scientific simulation studies to understand the forcing mechanism on tar ball transport between April to July i.e. considering the influence of wind, local tides, surface currents and south westerly monsoon system. It concluded from the studies that the trajectories of the oil particles or tar balls remain southeast bound in April-May; however, due to strong winds of the south-west monsoon in June-July the direction changes under the influence of winds and they reach the western coast. The occurrence of tar ball at Gujarat in April, and Goa between May to September are an example of the same pattern.

In view of the above, the Committee took on record the study finding that the offshore operations the Bombay High Oil Fields appear to be one of the major sources of oil spill and slicks, and the movement of ships (passenger and cargo) within the INDIAN jurisdiction in the eastern Arabian Sea, which eventually result in formation of tar balls and its deposition along the western coast of India.

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b. *Point no.2 - Review the current mechanism of addressing tar-ball problem at Indian coasts/ beaches and identification of gaps*

Current Mechanism - NIO Team presented that there is significant research available on tar ball pollution along the Indian coasts, focusing on source identification, transport patterns, and remedial measures. The investigations have utilized standard scientific tools like chemical fingerprinting and biomarkers to trace the source of tar balls. Research also indicate that microorganisms, particularly fungi and bacteria, utilize hydrocarbons in tar balls as a carbon source. Studies have identified diverse microbial genera associated with tar balls, some of which are known hydrocarbon degraders, which is a significant potential of bioremediation. Apart from this, several bacterial consortia have shown promising results in reducing n-alkanes and polycyclic aromatic hydrocarbon compounds in tar balls. The ONGC has recommended to use porphyrin compounds chelated with metals for doing tracing tar ball and oil spill sources. The Committee noted that as of now the tar ball problem is dealt at the level of State Government/ District Administration as and when the tar balls are washed towards the beaches/ coast. The tar balls are collected manually or semi-mechanically and transported to the authorized TSDF for incineration wherein the cost of disposal of tar balls is borne by the State Government. However, considering the ‘Polluter pays Principle’, there is need to put onus to meet the cost of disposal on the polluter.

Gaps – The Committee noted that there are challenges in understanding the nature and causes of oil spills, whether from operational mismanagement, pipeline leaks, or natural seepage. Non-availability of requisite infrastructure for tar ball cleanup require better coordination and communication among government agencies, and involvement of industry stakeholders involved in production of oil from offshore operations and oil cargo movements and other shipping operations. Additionally, public awareness, enforcement of environmental regulations and adequate reporting mechanisms are need to

allow concerned authorities to take required actions in a timely manner, in case an oil spill has happened.

The Committee was also of the opinion that clean-up infrastructure needs to be strengthened to undertake operations, at the earliest, with a view to save marine ecology.

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c. *Point no.3 - Suggest preventive measures required at source in respect of all scenarios like operation of off-shore oil fields, ship leakages/ discharges, oil spill events etc. to minimize leakage of oil/ petroleum materials that eventually lead to formation of tar-balls*

The Committee took on record the detailed list of preventive measures mentioned in the report w.r.t. various processes and scenarios like oil field operations, movement of ships, and oil spill events. It also noted that the concept of Environmental Sensitivity Index (ESI) for marine or coastal regions are utilized globally wherein a sensitivity assessment is done considering the presence of natural resources, such as birds, shellfish, drinking water intakes, corals, and coastal recreational areas in the geographical region. The report mentioned that depending on the character, type, and sensitivity of the shoreline and the physical and chemical properties of the oil (i.e., amount, type, and degree of weathering), various methodologies may be employed to mitigate an oil spill event. The oil deposited on a surface may be removed by manual methods such as a hand rake and shovel, sorbents, or by mechanical methods such as maintainers/ road graders and small front-end loaders, skimmers, and vacuum systems.

The authorities may develop a similar concept which can be introduced in the country with the help of research institutions to mark the sensitivity of an area, and can be identified as marine protected area. The Committee also noted that preventive techniques like the monitoring and assessment of oil spills through remote sensing and routine monitoring can help authorities to remain better prepared in case the oil spill happens in the sea, and the possibility of formation of tar balls to get washed up to the shore is there. Further, compilation of a time-series data on such scenarios can help developing mathematical models to make preparations in advance, and to have better decision making from policymakers and administrative authorities.

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d. *Point no.4 - Study of global best practices on prevention of tar balls formation and measures taken to contain tar ball pollution*

The study report mentions that the tar balls formation and its deposition on the coast is a common problem faced by many countries globally who are involved in offshore oil drilling operations or are near to the international routes of movement of ships, oil tankers and cargos. Accordingly, various measures have been taken by countries to address the pollution emanating from oil spill incidents and tar ball formation as mentioned below:

- Oil Spill Cleanup Plans and Expert Teams : Countries prone to oil spills have

established response plans, such as the Shoreline Cleanup Assessment Technique (SCAT) programs. Further, multi-agency expert teams, comprising representatives from different stakeholders are constituted to ensure a coordinated and quick response to oil spills.

- Implementing Regulations: Governments have enacted laws and regulations governing shipping, offshore drilling, and petroleum industries to prevent oil spills, which contain safety protocols and measures for prevention of oil spillage.
- Globally coordinated actions: International organizations like the International Maritime Organization (IMO) have set standards and guidelines for preventing and responding to marine oil pollution. It also have conventions viz. International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) and the International Convention for the Prevention of Pollution from Ships (MARPOL) to steer globally coordinated efforts for addressing marine pollution. Under the Global Maritime Distress and Safety System (GMDSS), ships are required to report any incidents that may lead to pollution or other environmental hazards.
- Contingency Plans and Environmental Impact Assessment: Companies must conduct environmental impact assessments and develop contingency plans before undertaking offshore drilling or major sea-based operations. In case of India, the National Oil Spill Disaster Contingency Plan (NOS-DCP) prepared by Indian Coast Guards outline responsibilities, resources, and arrangements for rapid response.
- Spill Response Equipment and Training: Organizations involved in marine operations must maintain oil spill response equipment onboard and provide regular training to personnel for spill-related emergencies.
- Improved Tanker Designs: Advancements in tanker design, such as double-hull tankers, aim to minimize the risk of oil spills.
- Use of Oil Spill Dispersants: Responders may use oil spill dispersants to break up oil layers into smaller droplets, reducing the likelihood of tar ball formation.
- Monitoring and Research: Continuous monitoring of oil-spill-prone areas and research on oil-spill impacts help improve response and prevention strategies.
- Suspended Oil Detection Methods: Detection technologies, including remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), assist in tracking submerged oil intrusion layers during spills. In situ measurements provide real-time data on the distribution of submerged oil, aiding response plans. Submarine devices like gliders, deep submerged vehicles, and ship-lowered rosettes with in situ sensors and cameras are also used to detect submerged oil in real time by measuring CDOM (colored dissolved organic matter), PAHs (polycyclic aromatic hydrocarbon), and DO (dissolved oxygen).

The Committee noted that despite taking these measures, the risk of oil spills and tar ball pollution remains, hence, it emphasized the need for a holistic approach that combines prevention with effective response and cleanup strategies. Advanced technologies, such as ROVs and AUVs, play a crucial

role in detecting and managing underwater oil plumes during spill events. It helps in inspection of oil rigs to find the location of the oil released, evaluate its degree of spreading, and identify the composition of the oil.

The Committee opined that the NOS-DCP can be updated to include new and advanced measures to effectively tackle the oil spill incidents, which eventually result in formation of tar balls also. Further, the State Government of a coastal state, which is required to constitute a State Level Crisis Management Group for management of oil pollution incidents, termed SOS-CMG direct the local administration (or authorities) or the concerned industry bodies (in consultation with local authorities) to set up a Shoreline Response Centre (SRC) based on the 'Polluter pays principle'.

The Committee further noted that previsions of OPRC and MARPOL may be effectively implemented by the Ministry of Ports, Shipping and Waterways. The MARPOL regulations aimed at preventing and minimizing pollution from ships are mentioned below:

- Annex I: Regulations for the Prevention of Pollution by Oil
- Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk.
- Annex III: Prevention of Pollution by Harmful Substances carried by Sea in Packed Form
- Annex IV: Prevention of Pollution by Sewage from Ships
- Annex V: Prevention of Pollution by Garbage from Ships
- Annex VI: Prevention of Air Pollution from Ships

Similarly, OPRC member states are required to establish measures for dealing with pollution incidents, either nationally or in cooperation with other countries. According to OPRC provisions, following measures are need to be taken:

- Ships are required to carry a shipboard oil pollution emergency plan
- Operators of offshore units are also required to have oil pollution emergency plans or similar arrangements which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents
- Ships are required to report incidents of pollution and details of the actions taken, in case such incidents happen, to coastal authorities and the convention
- Parties are required to assist others in the event of a pollution emergency, and provision is made for the reimbursement of any assistance provided.

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e. *Point no.5 - Suggest viable mechanisms to arrest tar-balls at Sea, based on global practices*

The study report mentions that the tar ball pollution is caused as an after effect of the oil spill or oil slick. Hence, the tar ball management strategy must focus on prevention of oil spills, and arresting the oil spill, in case such

incident happens. The tar ball formation is a delayed process after spillage of oil under the weathering action of atmosphere, sea water, currents, winds and chemical or biological agents. After the formation and movement of tar balls towards the beaches, the process of arresting at sea involves implementing mechanisms and technologies to collect, and remove tar ball pollution from the marine environment before it causes harm to the ecosystem and reach the coast or beaches. **The Committee noted that there are no mechanisms to arrest tar ball at high seas.** However, some of the below-mentioned techniques can help in containing the oil spills and tar ball pollution at sea.

- Shore sealing booms - Air and water-filled booms are used to seal the land and water connection, thus forming a temporary shore. Their deployment at marine sensitive zones or coast or beach can restrict depositions on the shore.
- Aerial Surveillance and Response - Aerial surveillance using choppers or drones can be used to monitor oil spills over large areas in the sea. By implementing advanced monitoring technology, floating tar balls, their movement, and trajectories can be detected, and information can be shared with coastal districts for quick response coordination and timely deployment of containment and clean-up facilities. However, aerial survey has limitations in detection of sunken or suspended tar balls.
- Bioremediation - Bioremediation is the method of introducing microorganisms for breakdown of oil, and facilitate the natural degradation of tar balls in the sea.

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f. *Point no.6 - Suggest introducing administrative and technical frameworks for monitoring/ under relevant statutes, in line with the Allocation of Business Rules of various nodal agencies*

The Committee noted that the Indian Coast Guard (ICG), Ministry of Defence is the central coordinating authority for combating oil spills in Indian waters as per the Government of India (Allocation of Business) Rules, 1961. The responsibilities of ICG cover the following:

a. Coordinating Agency for combating oil pollution in various maritime zones;
b. Implementation of a national contingency plan for oil spill disasters;
c. Surveillance of maritime zones for oil spills;
d. Combating oil spills in various maritime zones except within the jurisdiction of ports and oil installations; and
e. Undertaking oil spill prevention and control, inspection of ships (except within ports) and offshore platforms in the country.

The ICG has prepared a National Oil Spill Disaster Contingency Plan (NOS-DCP) outlining functional responsibilities for various Ministries and Departments of the Government of India, the State Governments and the District Administration in responding to oil spills in Indian maritime zones. The plan applies to incidents of marine casualties posing severe danger to the Indian coastline, covering deliberate, negligent, or accidental releases of oil,

ballast water, and harmful substances. The plan encompasses incidents in all parts of the sea and inland areas likely to affect India's maritime zones, including territorial waters, the Exclusive Economic Zone (EEZ), and the High Seas.

Based on the roles and responsibilities prescribed to various agencies under the NOS-DCP, the Committee noted that the following specific activities can be further delegated to the authorities:

Agencies	***Roles***
State Governments and District Administration	• *Undertake response activities, including cleaning and disposal, through involvement of relevant state level agencies viz. Transport, Coastal Zone Management, Environment and Forest Conservation, Resource Management, Environmental Protection Authorities, Emergency Services, Port/ Harbor Authorities* • *If required, Local Environmental Conservation and Civil Society Groups may be roped in the process.*
Indian Coast Guard (M/o Defence)	• *Undertake regular air and water surveillance of oil spill hot spots in high seas, and disseminate quarterly report to all relevant agencies, especially State Governments and District Administration* • *Send immediate emergency alerts on offshore oil spill events/ cases, if any*
Central Pollution Control Board (M/o Environment, Forest and Climate Change)	• *Render technical assistance to State Government and union Territories through the State Pollution Control Boards or Pollution Control Committees, in Accordance with the State-specific Contingency Plan.*
Ministry Of Ports, Shipping and Waterways and Directorate General of Shipping	• *Responsible to undertake or coordinate clean-up activities at ports, jetties, wharves, and other structures constructed within their jurisdiction, and at beach/ shoreline owned by the port authority* • *Take administrative and legal action for processing claims against expenditure or cost incurred by the Indian Coast Guard and other agencies in managing oil spill incidents* • *Develop Guidance to advise and facilitate other agencies in submitting claims the expenditure or cost incurred for managing pollution or oil spill from ships, including guidance on collection and submission of requisite evidence*
Ministry of Petroleum and Natural Gas through its Offshore Installations	• *Provide monthly oil leakage or spill incident reports of every installation (up to 500 meters) to ICG, nearby Coastal State Governments, including their State Pollution Control Boards or Pollution Control Committees, and Central Pollution Control Board*
National Remote	• *Undertake analysis on oil pollution around each and*

Sensing Agency	*every installation up to 500 meters and oil spill hot spots, and provide monthly reports ICG, nearby Coastal State Governments, including their State Pollution Control Boards or Pollution Control Committees, and Central Pollution Control Board*
Indian Council of Agricultural Research	• *Undertake research, and map the risks and consequences of tar ball pollution on fisheries and aquaculture, and compile related scientific evidence* • *Undertake research on devising measures to reduce the impacts of tar ball pollution on fisheries and aquaculture*

g. *Point no.7 - Prepare detailed Standard Operating Procedures (SOPs) for typical tar-ball sources like offshore Oil field operators, Passenger Ships/ Cargo Vessels, Oil Spill events etc., in alignment with the National Oil-Spill Disaster Contingency Plan (NOSDCP)*

The Committee took on record the Standard Operating Procedures (SOPs) mentioned in the study report for Offshore Oil fields, Movement of Ships and other oil spill events, and noted that the SOPs are aligned to the NOS-DCP, which is the standard protocol for coordinating oil spill incidents. It also noted that there is adequate guidance and regulations available under the OPRC and MARPOL convention also to prevent and manage oil spill incidences. Hence, the concerned agencies are required to implement the provisions in letter and spirit, and synergize their efforts. It is noted that the NOSDCP provisions on oil pollution preparedness and response requirements are categorized into three 'tiers':

- Tier 1 is concerned with preparedness and immediate response to a small spill within the capabilities of facility operator or port authority (oil spill Qty: <700Ton).
- 'Tier 2' describes a wide range of spill sizes and potential scenarios response assistance for which can come from entities within a port area or from national sources outside the immediate geographic area (oil spill Qty:>700 T - <10,000Ton).
- Tier 3 is concerned with a major spill requiring the mobilization of all available national resources and depending upon the circumstances, will likely involve mobilization of regional and international systems (more than 10,000 tonnes).

The responses are classified into three mechanisms viz. Mechanical containment or recovery, Chemical and biological methods and Physical methods. The mechanical containment is the primary line of defense against oil spills wherein containment and recovery equipment include a variety of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials. Mechanical containment is used to capture and store the spilled oil until its disposal. The chemical and biological methods can be used in conjunction with mechanical means for containing and cleaning up oil spills wherein dispersing agents and gelling agents are useful in helping to keep oil

from reaching shorelines and other sensitive habitats. The biological agents have the potential to assist recovery in sensitive areas such as shorelines, marshes, mangroves etc. The physical methods are used to clean up shorelines wherein natural processes such as evaporation, oxidation, and bio degradation can start the cleanup process, but are generally too slow to provide adequate environmental recovery. It primarily involves physical methods such as wiping with sorbent materials, pressure washing, and raking and bulldozing can be used to assist these natural processes.

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h. *Point no.8 - Suggest requirement and make recommendations with regard to the requirement of a corpus fund for undertaking shore cleaning up activities in the affected states.*

In view of the facts mentioned in the study report, the Committee unanimously noted and agreed that the formation of tar balls in the high seas is a natural phenomenon; however, its origin depends on the incidences of anthropogenic and natural oil spills and seepages. Accordingly, there is a need to arrest or manage the anthropogenic sources like offshore oil exploration activities, oil tanker accidents, oil-well blowouts, and pipeline leakages, release of bilge and industrial effluent from ships and tanker washes / leakage spills along tanker route. The Committee also noted that the NOS-DCP formulated by the Indian Coast Guard is the most comprehensive action plan available for coordination and management of oil spill incidents. The NOS-DCP not only provides for emergency measures for management of oil spills during an incident, but it also prescribes for adoption of preventive measures in synergy with other instruments like OPRC and MARPOL.

The Committee recommended that in view of the submissions made by the ICG that it is practically not feasible to arrest tar balls in high seas, the focus should be to collect, arrest and manage tar balls near sea shore and along the coast. Accordingly, the primarily responsibility of management of Tar balls should lie with the concerned coastal district authorities, supported by the concerned State Pollution Control Boards/ Pollution Control Committees. The State Coastal Management Authorities should become with State-level coordinating agency and the ICG should become the Central coordinating agency. The Committee also noted that the frequent episodes of tar ball washing ashore are noticed during summer-monsoon season i.e., Apil-September as the winds and currents are conducive for their transport to the shore, hence, the District-specific action plan for management of tar balls, including clean-up and disposal should prescribe enhance vigil and preparedness during the referred period.

The study report mentioned that tar ball cleaning can be performed in two ways:

- Manual tar ball removal – It involves the usage of hand tools such as shovels, rakes, pitchforks, and polypropylene drum liners. Manual removal is best for minimizing the volume of sand removed from the shoreline, therefore requiring less disposal.

- Mechanical tar ball removal – It involves the use of heavy equipment such as backhoes, excavators, bulldozers, and graders. Tar balls may be loaded into end-dumps, roll-off boxes, or other methods for disposal. However, an extensive care needs to be taken to protect ecology depending om shore sand/ sediment.

Thereafter, tar balls needs be disposed of either through co-incineration in a cement plant or in common incineration in the Treatment, Storage, and Disposal Facility (TSDF). **The Committee members, however, pointed out that considering the combustible nature of tar balls being derived from the oil spills or of petroleum origin, there is a need to further work on the utilization potential of collected tar balls waste. The Chair asked CPCB and NIO to further work on this aspect, and develop an SOP for the utilization of Tar Balls. In this regard, CPCB was asked to take lead and NIO was requested to provide required research and technical support.**

Cost of managing tar ball, including cleanup, collection and disposal

The Committee delved on the issue of bearing cost towards management of tar balls, as and when it happens, in detail and agreed that the 'Polluter pays principle' is required to be applied on such incidents. As evident from the finding of the study report, the major polluters in case of tar ball formation are offshore oil exploration activities covering oil-well blowouts, pipeline leakages, and movement of ships covering release of bilge and industrial effluent, tanker washes/ leakage/ spills along tanker routes, besides natural sources.

The Committee also noted that Hon'ble NGT had asked the Committee to deliberate on this issue, accordingly, the Committee made detailed deliberations and concluded that there is a need to provide support to relevant agencies in meeting the remediation cost of tar ball pollution. **The agencies that need to provide financial support for management of tar ball pollution are industries/ stakeholders engaged in the below-mentioned operations and activities with the jurisdiction of INDIA:**

- **Offshore crude oil production**
- **Oil transport pipeline infrastructure**
- **Coastal Refineries**
- **Ports, Harbors and Jetties, Wharves and other shipping infrastructures**
- **Coastal oil receiving facility operators, and operators of other ancillary activities**
- **Ships transiting through the hotspot zones identified in the study report, in general and Oil tanker ships, in particular**

Considering that there are many industries operating within the ecosystem of the offshore oil production, and that the movement of ships (passengers and cargo) within the INDIAN jurisdiction involves domestic as well as international ships, the Committee is of the view that MoPNG and MoPSW is best placed to devise a mechanism to

develop a corpus fund. The mechanism may address issues like criteria, admissibility, share of burden and utilization of funds. Since the tar ball pollution problem is limited to west coast, the stakeholders and operations limited to Gulf of Kuchchh, Gulf of Khambat, off Mumbai and western offshore, coastal refineries operating at Jamnagar, Vadinar, Mumbai, Mangalore, and Kochi, Major shipping companies (e.g. Shipping Corporation of India, Essar Shipping Limited, Great Ship India Limited etc.) and other relevant stakeholders.

The Committee emphasized the need to set up Shore Cleaning Centers in each coastal district, duly administered by the District Administration wherein the basic infrastructure required for managing tar ball pollution, including collection, transport and disposal, and manpower can be financially supported from the corpus fund.

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[1] *IMO – International Maritime Organization, MARPOL - International Convention for the Prevention of Pollution from Ships, and OPREC – International Convention on Oil Pollution Preparedness, Response and Co-operation*

'Records of Discussion' of the 2nd meeting of the Committee constituted by Hon'ble NGT in the matter related to the formation of Tar-balls along the coast of Goa, Gujarat, and Maharashtra

The 2nd meeting of the Committee constituted by Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to the formation of tar balls near the coast/ beaches of Goa, Gujarat, and Maharashtra was held on 17 January 2024. The meeting was co-chaired by Ms. Leena Nandan, Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC), and Shri Pankaj Jain, Secretary, Ministry of Petroleum and Natural Gas (MoPNG). The members of the Technical Sub-Committee (TSC) formed in this regard were also invited to the meeting. The list of participants is annexed.

2. At the outset, the Director (HSMD) welcomed all the participants and informed them that the issue under reference was related to an NGT case on tar-balls pollution. The Committee was updated that in line with the decision of the NGT Committee during its first meeting, a Technical Sub-Committee (TSC) was constituted which undertook deliberations with research institutes with domain expertise and relevant stakeholders and a study was conducted by NIOS with help of other expert Institutions. . The ToRs and study report covered the following aspects:

- Source identification
- Review of current mechanism and gaps
- Suggesting preventive measures
- Studying Global Best Practices
- Suggesting viable mechanisms for arresting tar-balls
- Administrative and Technical frameworks required to address the problem
- Standard Operating Procedures (SOPs) to address tar-ball sources
- Requirement of a corpus fund for tar-ball management

3. The Committee was informed that the TSC had worked upon a solution-oriented approach keeping in mind the principle of 'no-fault liability'. Hence, it has undertaken probabilistic source assessment using fingerprint analysis, remote sensing, Bio-markers and particle tracking simulation. Further, the report also touched upon the aspect of global best practices, current mechanisms of the National Oil Spill Disaster Contingency Plan (NOS-DCP), Gaps in the management of tar-balls, detailed preventive measures, and Standard Operating Procedures for various operations *(like oilfield operations, oil spills and ship movements),* additional responsibilities to stakeholders, etc.

4. The Committee undertook detailed deliberations on the issue, and noted the following:

- The origin of tar-balls or source identification needs to be further worked upon to remove any kind of doubt or ambiguity on the source of tar-balls as the area under reference i.e. west coast of India, is an international shipping route as well as an oil-rich area wherein many oilfields and commercial exploration activities are operational. The scientific tools utilized for tar-ball source assessment may be again investigated to arrive at conclusions that are scientifically acceptable in similar scenarios.
- The International Oil Pollution Compensation Fund (IOPC) is already operational under the auspices of the International Maritime Organization (IMO) to provide financial compensation for oil pollution damage that occurs in Member States, resulting from spills of persistent oil from tankers. Considering that the tar-ball formation is also an after-effect of the oil spills or leakages, it would be appropriate to explore whether the issue of tar-ball formation along the west coast of INDIA can be taken up with the IMO and IOPC, and expenditure towards management of tar-balls, including its cleanup, can be claimed thereunder.
- Commercial offshore oil exploration operations are industrial processes, and their routine compliance monitoring vis-a-vis applicable environmental regulations needs to be analyzed on a historical basis. Accordingly, the Pollution Control Boards (PCBs), Maritime Boards, and Coastal Zone Management Authorities (CZMAs) of Goa, Gujarat, and Maharashtra may be asked to share details for analysis. The Indian Coast Guard (ICG) may share their regular surveillance and monitoring observations about sources of oil spill incidences in the West Coast region. If required, additional ground-truthing can also be undertaken.
- There is a need for identification and fixation of the physical scope of the problem, i.e. the extent of the coastal area impacted by the tar-ball formations, no. of districts affected, tentative population impacted, broad assessment of the commercial and livelihood activities impact, and typical measures required to remedy the situation, monetary requirements of districts, before working upon the quantum of the proposed corpus fund.

5. Based on the deliberations, the Committee decided that TSC may take up the following issues through further study by the engagement of all relevant stakeholders:

- **To find the source of tar-balls by removing doubt or ambiguities through**

acceptable scientific source apportionment tools available.

- **To explore the utilization of the IOPC fund as a financing mechanism for management of tar-balls, for which India makes substantial contribution.**
- **To assess the environmental compliance of offshore oil exploration operations in general, and oil spill management in particular, through involvement of ICG, MoPNG, PCBs, Maritime Boards and CZMAs of Goa, Gujarat and Maharashtra. Additional ground-truthing can also be undertaken, if required.**
- **To assess leakages/spills by shipping lines in the west coast and fix their responsibility in formation of tar balls**
- **To identify and fix the physical extent of the affected area along western coast, covering details of districts, population, commercial and livelihood activities impacted, and enlist typical remedial measures based on which the actual requirement of districts for remedial measures and quantum of corpus fund can be worked out.**

The meeting ended with a vote of thanks to the Chair(s).

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F.No.11/22/2022-HSM
Government of India
Ministry of Environment, Forest and Climate Change
(HSM Division)

1st Floor, Jal Wing
Indira Paryavaran Bhawan
Jorbagh Road, New Delhi

Date: 24th April, 2024

Office Order

Sub: Constitution of Technical Sub-Committee (amendment) - reg.

The constitution of Technical Sub-Committee (TSC) has been slightly modified to replace Additional Secretary, MoPNG with Shri Sunil Kumar, Joint Secretary, MoPNG dealing with the subject of oil exploration, which is relevant to the issues being dealt under the NGT matter OA No. 73/2021 (related to tar balls formation). The revised constitution of TSC is mentioned below:

S.No.	Committee Member	Description
1.	Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC	Chairman
2.	Shri Sunil Kumar, Joint Secretary, MoPNG	Member
3.	The Member Secretary, Central Pollution Control Board	Member
4.	Dr. Suneel Vasimalla, Sr. Scientist, CSIR-National Institute of Oceanography	Member
5.	The Director, MoPNG (dealing with exploration related issues)	Member
6.	Representative of Ministry of Ports, Shipping and Waterways (Director level)	Member
7.	Representative, Indian Coast Guard (M/o Defence) (Director-level)	Member
8.	Dr. Prince Prakash Jeba Kumar J, Scientist, National Institute of Ocean Technology, Ministry of Earth Sciences	Member
9.	Representatives, Deptt. of Environment & Forest, State Govt. Goa, Maharashtra and Gujarat	Member
10.	Shri Ved Prakash Mishra, Director (HSMD), MoEFCC	Member Convener

2. The conditions, entries and 'Terms of Reference' of the aforesaid Office Order dated 5th May, 2022 (as amended) shall remain the same.

3. This issues with the approval of Competent Authority.

24/4/24

for (Ved Prakash Mishra)
Director

To:
All Members (As per the list)

Copy for information to:

- PPS to Secretary (EF&CC)
- PPS to AS (NPG)
- PS to Director (HSMD)
- IFD/ GC/ Budget Division/ SO (HSMD)/ Guard file

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List of Members:

S.No	Committee Member	Contact details
1	Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC	asnpg.mef@nic.in
2	Shri Sunil Kumar, Joint Secretary, MoPNG	jse-png@nic.in
3	Member Secretary, Central Pollution Control Board	mscb.cpcb@nic.in
4	Dr. Suneel Vasimalla, Senior Scientist, National Institute of Oceanography	suneel@nio.org
5	Director (Exploration), MoPNG	--
6	Director-level representative, Ministry of Ports, Shipping and Waterways	secyship@nic.in
7	Director-level representative, Indian Coast Guard (M/o Defence)	ddgops@indiancoastguard.nic.in
8	Dr. Prince Prakash Jeba Kumar J, Scientist, National Institute of Ocean Technology, Ministry of Earth Sciences	prince@niot.res.in
9	Representatives of Environment & Forest Departments of Goa, Maharashtra and Gujarat	Psec.env@maharashtra.gov.in Sec.forest@maharashtra.gov.in secfed@gujarat.gov.in Dir-env.gov@nic.in
10	Shri Ved Prakash Mishra, Director (HSMD), MoEFCC	Mishra.vp@gov.in

24/4/19

'Records of Discussion' of the 3rd meeting of the Technical Sub-Committee created to assist the Joint Committee constituted by the Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to formation of Tar-balls along the coast of Goa, Gujarat and Maharashtra

The 3rd meeting of the Technical Sub-Committee was held on 04-Sep-2024 at 11:30 AM in Narmada Conference Hall, MoEF&CC. The meeting was co-chaired by Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEF&CC) and Additional Secretary, Ministry of Petroleum and Natural Gas (MoPNG). The detailed list of participants is annexed at Annex-I.

2. At the outset, the MoEFCC representatives welcomed all the participants and briefed about the discussion held during the Joint Committee meeting held on 17.01.2024. The Technical Sub Committee discussed on the issues emerged out from the 2nd meeting of the Joint Committee and is of the view that:

i. It is difficult to exactly pinpointing the source of tar ball formation.

ii. There is a need for taking collaborative preventive and corrective measure to address this issue.

iii. TSC recommended that a rule shall be notified by the MoEF&CC under EPA to address the issues of Tar Balls and the broad contours of the said notification and other action required for the same are as follows:

- CPCB shall prepare a draft rules in consultation with other stakeholders.
- The rules shall provide the mitigative measures and responsibilities of various stakeholders.
- The rules shall provide the fund creation and contribution by various stakeholders.
- The rules shall provide the implementing, monitoring, auditing and reporting mechanism.
- The rules shall have a steering committee comprises of representative from Ministry of Environment, Forest and Climate Change (MoEF&CC), Ministry of Petroleum and Natural Gas (MoPNG), Ministry of Ports, Shipping, and Waterways (MoPSW), and Other stakeholders.
- CPCB shall submit the draft rules in the next meeting of Technical Sub Committee.

The meeting ended with a vote of thanks to the Chair(s).

Annex-I

List of Participants

1. Shri Naresh Pal Gangwar, Additional Secretary, MoEFCC
2. Shri Praveen Mal Khanooja, Additional Secretary, MoPNG
3. Shri Ved Prakash Mishra, Director, MoEFCC
4. Shri Amit Vashishtha, MoEFCC
5. Shri Dinabandhu Gouda, CPCB
6. Shri Raj Narayan Pankaj, Additional Director, CPCB
7. Dr. Suneel Vasimalla, CSIR-NIO, Goa
8. Shri SM Baidya, Ministry of Ports, Shipping and Waterways
9. Shri Sanjive Kumar, Principal Secretary, GPCB
10. Shri Seshan JS Exploration, MoPNG
11. Shri Sudharshan, ONGC
12. Shri Tilak Singh, ONGC
13. Shri Nikhil N Ray, ONGC
14. Shri Ajay Dixit, ONGC
15. Shri Mondal, ONGC
16. Shri Surendra, ICG

Records of Discussion of the 4th meeting of the Technical Sub-Committee created to assist the Joint Committee constituted by the Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to the formation of Tar-balls along the coast of Goa, Gujarat, and Maharashtra.

The 4th meeting of the Technical Sub-Committee was held on 04-April-2025 at 03:30 PM in Narmada Conference Hall, MoEF&CC. The meeting was co-chaired by Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEF&CC) and Additional Secretary, Ministry of Petroleum and Natural Gas (MoPNG). The detailed list of participants is annexed at Annex-I.

2. At the outset, the MoEFCC representatives welcomed all the participants and provided a background of the issue. Pursuant to recommendation of last meeting of Technical Sub-Committee, the CPCB prepared draft Tar Ball rules, presented it before the committee and made a presentation on draft rules.

3 . The Coast Guard made the following comments:

i. Broaden the definition of "tar balls" to include all potential sources, such as natural oil seepage, for a comprehensive understanding.
ii. Recommended refocusing it on shoreline tar ball management.
iii. The Central and State Pollution Control Boards (CPCB/SPCB) be made responsible for listing approved tar ball disposal facilities.
iv. Need for enhanced surveillance using SAR satellites for early detection in high-risk zones.

4. The Ministry of Petroleum and Natural Gas (MoPNG) has provided following inputs on the Draft *Tar Ball Management Rules, 2024*, focusing on improving both preventive and management strategies:

(i) Adoption of real-time tracking and leak detection systems in pipelines and tankers to proactively prevent tar-ball formation at the source.

(ii) Implementation of public alert systems by local authorities to warn communities during oil spill incidents, along with the use of weather forecasting and ocean current models to track and prioritize containment of oil spills.

(iii) Inclusion of "innovative non-toxic oil recovery methods" to strengthen preventive mechanisms at sea.

(iv) Enhance real-time responsiveness, community safety, data tracking, and long-term effectiveness in managing tar-ball pollution and its environmental impact.

5. Ministry informed that the legal basis for the creation of corpus fund is through Environment Protection Act, 1986. The Ministry also informed that rules will be put for public consultation once the Joint Committee approves the proposal of Technical Sub Committee to formulate a rules to address the issues of Tar Ball, and accepted by NGT.

7. **Based on the discussion held and presentation made the Technical Sub Committee made following recommendations**:

a) The draft rules submitted by CPCB are broadly acceptable and should be improved upon based on the discussions in the meeting and comments received, within 10 days.

(Action Point : CPCB)

(b) The modified draft rules will be presented before Joint Committee constituted by NGT as report/recommendation of the TSC. (Action Point: MoEFCC)

b) Once approved by Joint Committee, final report will be submitted before NGT recommending notification of Tar Ball rules to address the problems. If agreed by NGT, draft rules will be processed and issued by MoEFCC after due consultation with stakeholders. (Action Point: MoEFCC)

(d) In the meantime, an interim report will be filed before the NGT. (Action Point: MoEFCC)

The meeting ended with a vote of thanks to the Chair.

Annex-I

List of Participants

1. Shri Naresh Pal Gangwar, Additional Secretary, MoEF&CC

2. Shri Praveen Mal Khanooja, Additional Secretary, MoPNG

2. Shri Ved Prakash Mishra, Director, MoEF&CC

3. Shri Amit Raj, Director, MoEF&CC

4. Shri Amit Vashishtha, Scientist-E, MoEF&CC

5. Shri Naresh Tanwer, SSA, CPCB

6. Shri Bharat Kumar Sharma, Member Secretary, CPCB

7. Shri Nazimuddin, Sc. F & DH, CPCB

8. Shri SK Karwasara, Indian Coast Guard/MOD

9. Dr. Prince prakash jebakumar J, NIOT

10. Smt. Vinita Vaid Singal, PS , Env.& CC,GoM

11. Shri Shankar Waghmare, Joint Director, MPCB

12. Shri Suneel, CSIR - National Institute of Oceanography

Records of Discussion of the 5th meeting of the Technical Sub-Committee created to assist the Joint Committee constituted by the Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to the formation of Tar-balls along the coast of Goa, Gujarat, and Maharashtra.

The 5th meeting of the Technical Sub-Committee was held on 16-September-2025 at 03:30 PM in Narmada Conference Hall, MoEF&CC. The meeting was chaired by Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEF&CC). The detailed list of participants is annexed at Annex-I.

2. At the outset, the MoEFCC representatives welcomed all the participants and provided a background of the issue. Pursuant to recommendation of last meeting of Technical Sub-Committee, the CPCB shared the modified Draft Tar Ball rules, which were reviewed by the Ministry of Environment, Forest and Climate Change and it was decided that the MoEFCC would revise and finalize the Draft Rules. The revised Draft Tar Ball Rules were again shared for Inter-Ministerial Consultation during June 2025 and Suggestions/Comments were received from: (i) Coast Guard Headquarters (ii) Dr. Prince Parkash Jebakumar, NIOT (iii) Director, Environment and Environment Engineer, Department of Environment and Forests, Gandhinagar (iv) MoPNG and (v) MoPSW.

3. The inputs received from various stakeholders were examined in the Ministry and necessary provisions were duly incorporated into the revised Draft Rules. The updated draft, was shared with the concerned Ministries and Departments on 15 September 2025, a day prior to the 5th TSC meeting. During the meeting, the revised draft rules were discussed in detail. The State Government of Maharashtra informed that their inputs have also been shared on 16.09.2025 morning. During the meeting, it was suggested that:

a) CPCB should prepare a Model SOPs and State Government if required adopt the same or modify the same as per their local requirements/situations.

b) to add by any other means in the rule 10.

c) Rule 11 should also include operator.

d) In Rule 12 provision for utilising the existing TSDF may be provided and frequency of inspection by SPCBs may be re-verified from CPCB.

e) In rule 21 it was suggested that EC may imposed by SPCB/PCC in place of CPCB and rule 21(7) may be omitted.

f) Rule 26(2) on Appeals needs to be checked or omitted if required.

4. Based on the discussion held and presentation made the Technical Sub-Committee made following recommendations:

a) The HSM Division shall carry out the minor changes suggested in the draft rules and the modified draft rules be presented before Joint Committee constituted by NGT as report/recommendation of the TSC.

b) Once the Joint Committee approves the proposal of TSC for the publication of the rules for the management of Tarballs, the Ministry may take further necessary

action for publishing the draft rules for public consultation and a report on behalf of Joint Committee be submitted before NGT along with the relevant documents.

The meeting ended with a vote of thanks to the Chair.

Annex-I

List of Participants

1. Shri Vir Vikram Yadav, Additional Secretary, MoEF&CC
2. Shri Neelesh Kumar Sah, Joint Secretary, MoEF&CC
3. Shri Amit Raj, Director, MoEF&CC
4. Shri Amit Vashishtha, Scientist-E, MoEF&CC
5. Shri Nazimuddin, Scientist F & DH, CPCB
6. Shri V.C. Chowdhary, Deputy Director, MoPNG
7. Shri Satish Kamath, DGS, MoPSW
8. Shri Shubham, GSPCB
9. Dr. Suneel Vasimalla, CSIR-NIO, Goa
10. Comdt Surendra, Indian Coast Guard
11. Ms. Chriselda Rodrigues, Dept. of Environment & Climate Change, Government of Goa
12. Dr. Y B Sontakke, Joint Director, WPC-MPCB's
13. Dr.Prince prakash jebakumar J, NIOT
14. Representative from Environment Department Maharashtra
15. Representative from Maharashtra Pollution Control Board
16. Representative from Goa Pollution Control Board
17. Shri Aman Kohli, Legal Associate, MoEF&CC

Records of Discussion of the 3rd meeting of the Joint Committee constituted by Hon'ble NGT in the matter of Brackish Water Research Centre Vs Gujarat Pollution Control Board & Ors. (OA No.73 of 2021) related to the formation of Tar-balls along the coast of Goa, Gujarat, and Maharashtra.

The 3rd meeting of the Joint Committee constituted by Hon'ble National Green Tribunal (NGT), in OA No. 73 of 2021 (*Brackish Water Research Centre vs. Gujarat Pollution Control Board & Ors.*), related to the issue of Tar Ball formation along the west coast of India, particularly in the states of Gujarat, Maharashtra, and Goa was held on 25.11.2025. The meeting was co-chaired by the Secretary, Ministry of Petroleum and Natural Gas (MoPNG) and the Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC). The list of participants is enclosed as **Annexure I**.

2. At the outset, the Director (HSMD) welcomed all the participants and informed about the directions of the Hon'ble NGT in the OA No. 73 of 2021. The committee was informed that after the 2nd meeting of the Joint Committee, the Technical Sub-Committee (TSC) has conducted its 3rd, 4th and 5th meetings. In the 3rd meeting of the Technical Sub-Committee (TSC) held on 04.09.2024, the Committee acknowledged the challenges in pinpointing sources and emphasized the need for collaborative, preventive, and corrective actions. It was recommended that Central Pollution Control Board (CPCB) may develop draft rules for Tar Balls under the Environment (Protection) Act, 1986, thereby providing the provisions for mitigation & preventive measures, stakeholder responsibilities, fund creation & contribution by stakeholders, implementing, monitoring, auditing and reporting mechanisms. Further, draft rules also include provision for a Steering Committee comprising MoEF&CC, MoPNG, MoPSW, and other stakeholders.

3. In the 5th meeting of TSC held on 16.09.2025, the revised draft rules were discussed in detail and it was decided that the modified draft rules be presented before Joint Committee constituted by NGT as report/recommendation of the TSC.

4. The Joint Committee was informed that Hon'ble NGT through its order dated 09.09.2025 has granted a final extension of three months for submission of documents including draft rules.

5. During the 3rd meeting of Joint Committee, the committee discussed in detail the provisions of the draft rules finalised by the TSC in its 5th meeting. Committee suggested that the statutes referenced in the Draft Rules be reviewed to assess their scope and applicability. Only relevant statutes are to be retained. The Committee further advised that, instead of introducing the District Shoreline Response Centre/Committee mechanism, the role of the local administration, particularly the District Disaster Management Authority (DDMA) be examined for inclusion in the Draft Rules. Strengthening the involvement of district-level institutions would ensure faster on-ground response and improved coordination during tar ball incidents.

6. It must also be explored whether it can be notified as man-made disaster under the Disaster Management Act.

7. It was recommended that the feasibility of including management of Tar Ball pollution in the respective District Disaster Management Plans may be explored.

8. The Committee agreed that the Steering Committee should have the flexibility to co-opt a knowledge partner or subject matter expert as a member, whenever required.

9. On the issue of the proposed corpus fund, the Committee suggested that additional options and agencies be explored as potential contributors. A diversified funding mechanism would ensure adequate financial resources for timely response, mitigation, and clean-up operations related to tar balls.

10. During discussions on disposal mechanisms, the Committee raised queries regarding the economic feasibility of establishing new TSDF facilities exclusively for tar ball disposal, including whether such operations would be financially viable and at what rate tariff fixation could occur. It was clarified that the Draft Rules do not mandate the creation of new TSDF facilities; instead, disposal may be undertaken through existing authorized TSDFs.

11. The Joint Committee considering the above, agreed in principle with the provisions of Draft Rules and recommended that no further meeting of Joint Committee is required and the Ministry shall revise the draft rules to include the suggestions made during the meeting and initiate the process for public consultation, in accordance with the Environment (Protection) Act, 1986. An affidavit along with the notified draft rules shall be submitted before the Hon'ble Tribunal. It was also decided to circulate a copy of the draft rules along with the Minutes to all concerned so that their inputs, if any, may be obtained expeditiously for finalisation of the Rules.

12. The meeting concluded with a vote of thanks to the Chair and all participants.

Annexure-I

List of Participants

Shri. Pankaj Jain, Secretary, MoPNG

Shri. Tanmay Kumar, Secretary, MoEFCC

Shri Vir Vikram Yadav, Addl. Secretary, MoEFCC

Shri. Praveen Mal Khanooja ,Addl. Secretary, MoPNG

Shri. Neelesh Kumar Sah, Joint Secretary, MoEFCC

Shri. Vinod Seshan, Joint Secretary, MoPNG

Shri. Bharat Kumar Sharma, Member Secretary, CPCB

Shri. Sanjeev Kumar, Secretary, Gujarat Forest & Environment Department (virtually)

Shri Sanjiv Gadkar, Linking Secretary, Goa Environment & Climate Change Department (virtually)

Shri. Amit Raj, Director, MoEFCC

Dr. Suneel Vasimalla, CSIR-NIO, Goa (virtually)

Shri. Abhay Pimparkar, Director, Maharashtra Environment Department (virtually)

Records of Discussion of the Meeting on provision of Corpus Fund under Tar balls Rules

A meeting under the Chairmanship of Shri Vir Vikram Yadav, Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEF&CC) was held at 12:30 PM on 23.12.2025 in Indus Conference Hall, MoEFCC to discuss the provision of Corpus Fund under draft Tar Balls Rules. The detailed list of participants is annexed at **Annex- I**.

2. At the outset, the Director, HSMD welcomed all the participants and briefed them on the background of the issue. It was informed that the draft *Tar Balls Rules* have been placed before the Joint Committee in its meeting held on 25.11.2025. With regard to the proposed corpus fund, the Joint Committee had suggested that additional options and agencies be explored as potential contributors. It was emphasized that a diversified funding mechanism would ensure the availability of adequate financial resources for timely response, mitigation, and clean-up operations related to tar balls.

3. During the meeting, it was observed that the option proposed such as NDRF, SDRF, and the Oil Cess Fund as potential contributor may not be considered for this purpose. It was suggested that the Ministry of Ports, Shipping and Waterways (MoPSW) provide the necessary budgetary support. It was further proposed that the State Pollution Control Boards (SPCBs) / Pollution Control Committees (PCCs)/State Authorities may initially incur the expenditure and subsequently seek reimbursement from the Corpus Find under MoPSW. The Central Pollution Control Board (CPCB) was requested to issue guidelines on the utilization/disbursement of the corpus fund.

4. There was a common agreement among the participants on the above proposal. The representatives of MoPSW was requested to share views on the creation and management of the Corpus Fund as mentioned in the Draft Tar Ball Rule. The representative of MoPSW sought additional time to furnish comments, in discussion with DG, Shipping.

5. The JS(HSMD) observed that, with respect to the draft Tar Ball Rules including creation of the corpus fund, MoPSW had already conveyed its comments vide Office Memorandum dated 30.07.2025, wherein no objection was raised to the creation of the corpus fund by MoPSW. It was further noted that the representative of MoPSW had attended the 5th Meeting of the Technical Sub-Committee held on 16.09.2025, during which the issue of creating a corpus fund was discussed and no

objections were raised. The Chair noted that the matter had been discussed over a considerable period and reiterated that it would not be appropriate to revisit settled issues at this stage.

6. Accordingly, the Chair directed to take up the matter with MoPSW for their comments by 24th December, 2024.

The meeting ended with vote of thanks to the Chair.

Annex-I

List of Participants

1. Shri Vir Vikram Yadav, Additional Secretary, MoEF&CC
2. Shri Neelesh Kumar Sah, Joint Secretary, MoEF&CC
3. Shri Amit Raj, Director, MoEF&CC
4. Shri Amit Vashishtha, Scientist-E, MoEF&CC
5. Dr. Veer Dnyaneshwar Tukaram, Controller of Accounts, MoEF&CC
6. Shri Bharat Kumar Sharma, Member Secretary, CPCB
7. Shri Nazimuddin, Scientist F & DH, CPCB
8. Shri Bhupender Kuamr, Director (Exp-I), MoPNG
9. Shri G.L. Das, HOD (RCC), MoPNG
10. Commandant Kundan, JD (FE), Indian Coast Guard
11. Smt K R Mangalaa, Scientist D, Ministry of Earth Science
12. Dr. Nilesh Pawar, Deputy Director (Aquatic Quarantine), Department of Fisheries
13. Shri L.K. Rajak, Chief Engineer, Inland Waterways Authority of India
14. Dr. Prince Prakash Jebakumar J, NIOT
15. Shri Dinesh Kumar, Dir (PD-I & IV), MoPSW
16. Shri Pravin Kumar Roy, Engineer & Ship Surveyor-cum-Deputy DG(Tech), MoPSW
17. Shri Satish Kamath, Dy. Chief Surveyor-cum-Senior Deputy Director General

(Tech), MoPSW

18. Shri Vinod Kaushik, National Disaster Management Authority (NDMA)
19. Smt. Dipali Tank, Director (Environment) & Member Secretary, Gujarat Coastal Zone Management Authority
20. Shri D.M. Thanker, Member Secretary, Goa Pollution Control Board
21. Shri Ramesh M. Manale, Joint Secretary, Government of Maharashtra
22. Shri. Jagannath Shankar Salunkhe, Maharashtra Pollution Control Board
23. Shri Ayaan Husain, Consultant, MoEF&CC

Minutes of the meeting held on 31.12.2025 at 12:30 p.m.on the proposed corpus fund under draft Tar Balls Management Rules of MoEFCC

The detailed list of participants is placed at Annexure-I.

2. At the outset, all participants were welcomed and briefed on the subject for discussion. the proposal relating to creation and location of a Corpus Fund under the Draft Tar Balls Management Rules for management of tar ball incidents.

3. JS, MoEF&CC informed that the proposal for a corpus fund emanates from recommendations of the Joint Committee constituted in compliance with directions of the National Green Tribunal (NGT). It was stated that the Committee deliberated upon the issue of Tar Balls remediation and recommended exploration of a corpus fund mechanism related to tar balls management.

4. The Directorate General of Shipping (DGS) informed that :

i. in cases where Tar Balls can be attributable to ship-source pollution, there are effluent treatment equipments fitted onboard ships to keep the operational pollution to a minimum and well below MARPOL convention norms specified. Also, an established compensation mechanism already exists for oil spills due to ship accidents under international conventions, including MARPOL and the International Oil Pollution Compensation (IOPC) Funds,

ii. the Oil Importers are annually contributing towards IOPC funds. As such, contribution towards the proposed corpus fund is not desirable,

iii. claims for reimbursement of expenditure incurred by State Governments can be submitted to IOPC Funds, subject to scientific confirmation of ship-source pollution by the Pollution Control Boards,

iv. scientific attribution of Tar Balls to a specific source is technically challenging, as studies indicate that Tar Balls may originate from multiple sources, including oil exploration activities, refinery discharges, and shipping-related incidents. It was emphasized that shipping is not the predominant source in all such cases.

5. DGS also highlighted legal and institutional constraints**,** stating that:

i. creation of a fund through rules requires explicit enabling provisions through enactment of specific Act which need to be formulated by MoEF&CC,

ii. MoPSW/DGS does not have a district-level administrative mechanism to administer a corpus fund or oversee on-ground remediation activities, which are primarily undertaken by District Administration and State Governments in coordination with State Pollution Control Boards.

6. In view of the above, MoPSW reiterated its reservation regarding administering a corpus fund under MoPSW. It was suggested that, if a corpus fund is considered necessary, it may be more appropriately placed with MoEF&CC or MoP&NG or

784 alternatively referred to in the rules in a generic manner, without naming a specific Ministry.

7. It was considered that the Draft Tar Balls Management Rules may be suitably modified by MoEF&CC in the light of above observations before issuing them for public consultation and seeking comments from stakeholders.

The meeting concluded with a vote of thanks to the Chair and all participants.

Annexure-I

List of Participants

MoPS&W

1. Shri Rajesh Sinha, SS
2. Shri P.K.Roy, Joint Secretary,
3. Shri Devendra Kumar, Dy. Secretary
4. Shri Anadi Sharma, Under Secretary

MoEF&CC

5. Shri Neelesh Sah, Joint Secy
6. Shri Amit Raj, Director, (HSMD)
7. Shri Amit Vashishtha, Scientist 'E' (HSMD)

DGS

8. Shri Ajith Sukumaran, Chief Surveyor
9. Captain Abul Kalam Azad, Nautical Adviser
10. Shri Satish Kamath, Dy CS & Sr. DDG(Tech)

CoPA/DPA/IPA

11. Deputy Chairman, DPA
12. Representative from MPA
13. Representative from CoPA
14. Shri Arun Kumar, CAO, IPA