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Analyzing Impact and Management of Tar Ball Pollution along Alibaug Coastline (Maharashtra)"

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Abstract: ***Coastal line is a boundary line between land and water surface. Many studies reported effect of oil spill pollution on different beaches. It is important to study effect of oil spills pollution because this phenomenon produces a very damaging effect on the ecosystem of beaches. This pollution reduces natural biodiversity of beaches also it reduces progress of tourism industry. This study focuses on occurrence of tar balls on the beaches of Alibaug region, in the Arabian sea of India.This project also includes the impact of oil spills on the coastal ecosystem of Alibaug but other effects like social and financial will not be analyzed. Large numbers of tourists visit to Alibaug beaches region. But in today's age, because of marine pollution and problems like oil spillage from ship accidents, Alibaug beaches also get affected by problems of pollution. Oil spill accidents are increases day by day because increase in transportation of oil through ships. Impact assessment was carried out by conducting field survey along different beaches along Alibaug Coastline. One clean up system used to minimize oil spill pollution effects is also explained. Also some testing's also included in this project by compability with bituminous properties.This project gives general information of oil spill pollution along Alibaug coastline,from which, it is possible to adopt preventive measures to reduce number of oil spill accidents.***

Keywords: Tar balls, oil spill, spillage, oil spill accidents, marine tar.

I. INTRODUCTION

India has approximately 8110 km long coastline. **Varkey, Sukhdhane et al. (1999)** reported that the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal and Tripura share nearly an equivalent coastline [21]. Figure 1 shows map of coastal districts in India. In this study coastline of Alibaug beach (Raigad District) is analyzed. In previous couples of years Alibaug has become one of the major tourist destination places. Hence, it is necessary to study marine pollution at Alibaug Beach. The Latitude and the line of Longitude of Alibaug are 18.39 N and 72.55 E. Figure 2 shows map of Study Area. The problem of oil spillage was first time observed at Alibaug in August 2010, after collision between MSC Chitra and MV Khalijia 3 ships near Mumbai coast on Saturday 7 August 2010 at 9.50 a.m. local time. Alibaug coastal areas are continuously changing by effect of climate, light, wind, weather and other physical and chemical factors.

Figure 1: Map of coastal districts in India.
(https://www.researchgate.net/figure/Coastal-districts-of-India_fig1_271014182)

From last few years transportation of oil is done through waterway i. e by ships only, because of these oil spill accidents are increases day by day. It is difficult to predict oil spill when it happens hence it is necessary to adopt some control measure to reduce numbers of oil spill accidents. Oil spill pollution produces harmful effects on the environment, the wildlife and coastal communities. In addition to oil spill accidents other reasons like offshore drilling operation and exploration activities also responsible for oil spill pollution. Coastal state government has required preparing some effective measures to reduce and minimize social, economical and environmental effects of oil spill for reducing number of oil spill accidents.

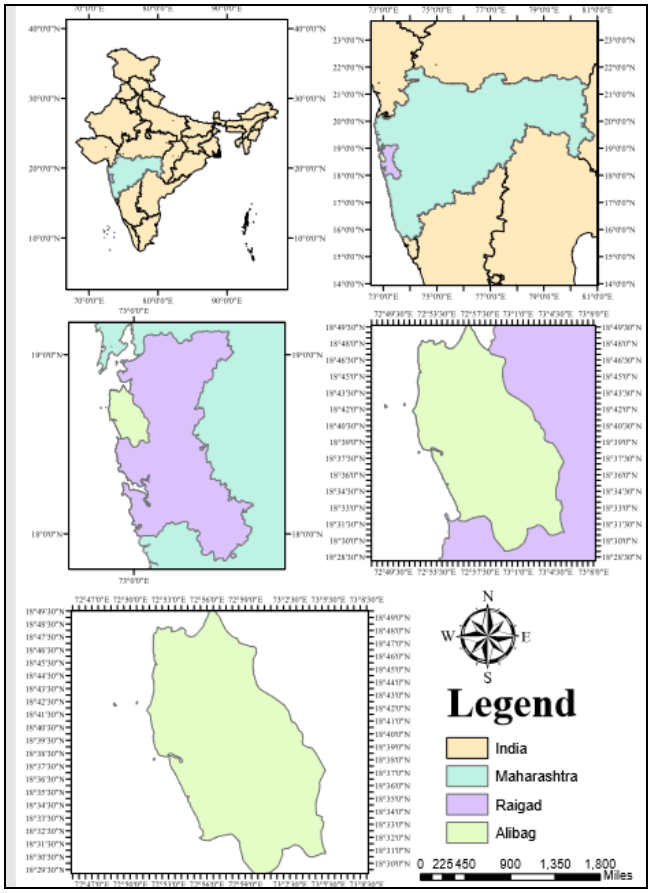

Figure 2 : Map of Study Area

II . FORMATION PROCESS OF TAR BALLS

In addition to ship accidents, other reasons of immersion of oil in marine environment are like, operational discharges during offshore drilling, rupture in oil pipelines and seepage from seabed. It is observed that ocean received about 0.47-8.40 million tonnes of oil annually. The substances which are formed after releasing oil into coastal environment by any artificial or natural activities are known as tar balls[7]. Tar balls are spherical in shape, black in colour and solid or semi solid in nature. A simple image of Tar ball residue is as shown in below Figure 3.

Figure 3 : Observed Marine Tar

Different physical, chemical and biological processes included in formation process of tar balls [9]. It includes spreading of oil, evaporation, dissolutions, sedimentation, emulsification etc. The chemical and biological processes consist of process like

photo-oxidation or photo-degradation respectively. Tar balls have solid consistency and its size varies from millimeter to centimeters.

III. PROBLEM STATEMENT

Tar ball pollution is most dangerous in today's age. pollution. It consists of formation process of tar balls and their effects on ecosystem. It also includes some testing which was carried out on mixture of bitumen and marine tar. It is necessary to study more about effects produced due to presence of fresh oil marine residue as compared to effects produced due to weathered, coherent marine tar residue.

- **Effects on Human Life**

In recent years some of the researchers found new issue regarding human health with contact of tar ball [7]. They conducted laboratory analysis on number of tar balls samples for counting total numbers of aerobic bacteria. They observed higher count in sea water tar balls than in sand tar balls. In addition, vibrio vulnificus , is a bacteria that can cause severe illness in humans. These bacteria found in 100 times higher in sand tar balls than seawater. Because of this tar balls negative impact is produced on tourism industry. People do not like visiting such beaches which are covered with tar balls because tar balls can stick to feet and at a minimum serves as an unpleasant visual reminder of environmental pollution. Hence, it is necessary to reduce the amount of tar balls on beaches to decrease negative impact on tourism. Because of this economic loss is associated with tar balls pollution.

- **Effect on Aquatic Life**

At an evening of 24th June 2015, Konkan Cetacean Research Team found the largest animal called a blue whale, in the shallow waters of Revdanda beach shown in Figure 4. With official permission the Revdanda villagers and the persons from district collector's office try to push this aquatic animal into the sea. But it is died on 25th June 2015.The entire process was carried out without a defined protocol or necessary safety equipment. Also from last few years ago Live and dead groups of marine animals like fish, turtles etc. are found along Arabian sea.

Figure 4: Observed Blue Whale at Revdanda Beach

IV. OBJECTIVES OF STUDY

The main purpose of this study is to minimize effects produced because of presence of tar balls. Hence to achieve the main research objective some objectives are required to be accomplished as follows:

- To study the sources of marine pollution along Coastline [8].
- To study the impact of tar ball pollution on the ecosystem of Alibaug coastline.
- To identify certain properties of marine tar.
- To study clean up assessment system used to reduce quantity of marine tar.

To achieve our objectives, different assessment phases were included in methodology of this project. First phase includes assessment of data and collection of tar ball samples by conducting ground survey at different beaches in Alibaug region. Second phase includes analysis of collected data by conducting some laboratories testing's. Last step include adoption of clean up assessment system and detection of oil spill location by using satellite images.

V. CASE STUDIES

First assessment phase carried out on three beaches namely Kihim, Revdanda and Mandwa beach of Alibaug Coastline.

- **Kihim Beach**

It is located approximately 11 km from Alibaug City in the north direction. Its location is shown in Figure 5. The latitude of Kihim village is 18.72 N and longitude 72.86 E.

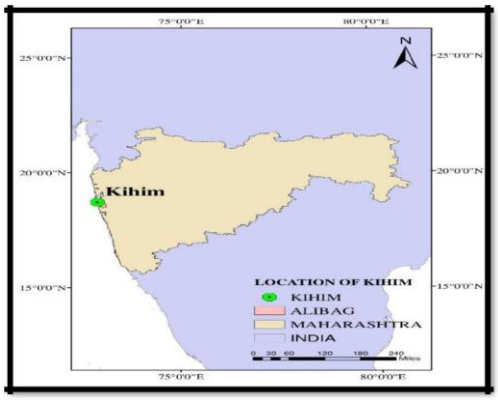

Figure 5: Map shows location of Kihim Village

First step of methodology that is first phase assessment was carried out at Kihim Beach in the second week of February 2018. The observed tar balls at this beach are shown in Figure 6 (a) and (b) . Even though tar balls are seasonal phenomenon means these balls observed mostly in monsoon season. But even in February month, there was huge numbers of tar balls in at the coastline of Kihim beach. The colour of observed tar balls is black having average size from 3 to 7 cm. Tar balls are mostly spherical in shape but most of them are ellipsoid in nature. Tar balls observed at this beach are benthic in nature, means they are observed at sea shore. The density of tar balls increases in monsoon season.

Figure 6 (a) and (b): Observed Tar balls at Kihim Beach

- **Revdanda Beach**

Revdanda beach is one of the popular beach in Alibaug region**.** The sand observed at this beach is black in colour which gives it unique look. It is situated at 17 km distance from Alibaug city.The location of Revdanda Village is shown in Figure 7.The lattitude and longitude of this beach are 18^{O} 33´ N and 72^{O} 56´E respectively. First phase assessment at Revdanda Beach was completed in March 2018.Figure 8 shows observed oil spill at RevdandaBeach.

Figure 7 : Location of Revdanda Village

Figure 8: Observed Oil Spill at Revdanda

VI. DEGRADATION METHODS OF TAR BALL

Generally for disposal of marine tar methods like combustion, physical removal or mechanical method are used as shown in Figure 9 [7]. When possible combustion is a most useful or mostly adopted process involved in degradation of Tar balls. But combustion process is not suitable for residual tar balls . Removal of tar balls by physical methods involves methods like burial method and offshore submersion. Manual method of tar ball removal is effective but labor intensive. Mechanical methods like those which are involved in DWH cleanup by using beach equipment. Initially use of DWH vehicle during cleanup process results in breaking up of the tar residues into smaller fragments that passed through the shifting mechanism for further processing.

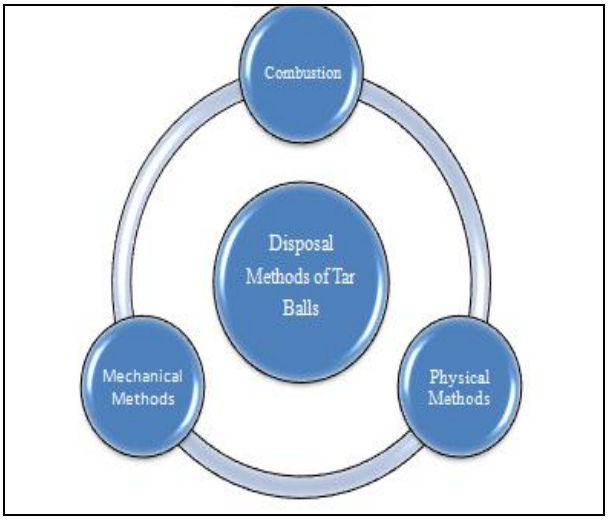

Figure 9 : Degradation Methods of Tar Balls

VII. EXPERIMENTAL ANALYSIS

Disposal of marine tar balls is little more complicated process. Different disposal methods of tar ball include method like manual method, burial method, mechanical method etc. But, the disadvantage of this method is it produces harmful effect on marine ecosystem. Hence, to avoid this harmful effect it is beneficial to use marine tar residue in bituminous road construction. Marine tar residue i.e. marine tar balls contains naphthalene hence, it shows same properties as bituminous material. In this project Penetration test and flash and fire test on mixture of marine tar residue and bitumen was performed by using standard procedure. For these testing mixture is prepared by heating bitumen of grade A 65 (A- American Petroleum) and marine tar at about 75^{o}c to 100^{o} C temperature . Three samples were taken for analysis, sample 1 consist of 50 gm bitumen and 50 gm marine tar, Sample 2 consist of 80 gm bitumen and 20 gm marine tar whereas Sample 3 consist of 70 gm bitumen and 30 gm marine tar .

PENETRATION TEST

Penetration value means measure of degree of hardness or softness in mixture of marine tar and bitumen. It can be determined by using Standard Penetrometer Apparatus. The Penetrometer includes a 100 gm needle as well as releasing and locking mechanism. The time required for penetration of needle is considered as 5 seconds. After conducting penetration test on three specimens with 50:50, 70:30 and 80:20 proportion mixture, then obtained results as per BIS Standards are 70 mm,60 mm and 55 mm on sample 1 ,2 and 3 respectively as shown in Table 01 and in Figure 10 graphically.

Table 01 : Results of Penetration Test

Sample No.	Bitumen (gm)	Marine Tar (gm)	Penetration Value (mm)
1	50	50	70
2	70	30	60
3	80	20	55

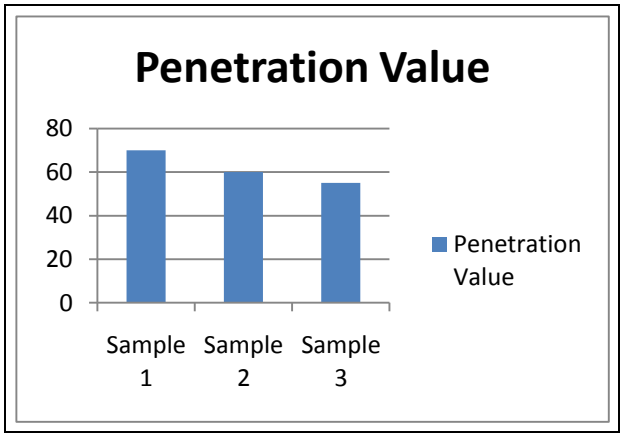

Figure 10: Graph for Penetration Value of Marine Tar and Bitumen Mixture

FLASH AND FIRE POINT TEST

Fire point of bitumen is a temperature at which vapours of bitumen catch the fire. Pensky Marten Apparatus used for determining Flash and Fire Point Test. Same proportion of mixtures were used for Flash and Fire Point Test as mentioned in above test. Test was carried out as per procedure of BIS Standards. The obtained results are tabulated as shown in Table 02 and in Figure 11 graphically. For Sample 1, the readings obtained for flash and fire point are 210 ^{o} C and 220 ^{o}C respectively and for Sample 2, readings obtained for flash and fire point are 200 ^{o} C and 210 ^{o}C respectively and for last sample, the readings obtained for flash and fire point are 180 ^{o} C and 190 ^{o} C respectively.

Table 02: Results of Flash and Fire Point Test

Sample No.	Bitumen (gm)	Marine Tar (gm)	Flash Point Value (^{o}C)	Fire Point Value (^{o}C)
1	50	50	210	220
2	70	30	200	210
3	80	20	180	190

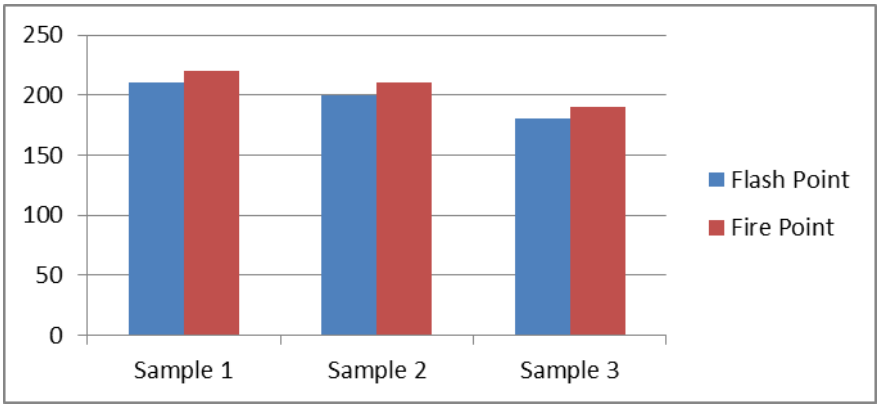

Figure 11: Graph for Flash and Fire Point Value f mixture

VIII. Use of Remote Sensing In Detection of Oil Spill Location

Remote Sensing is a necessary part in detection of oil spill location. It is precious to locate extent of the oil spill. Different technologies are available to monitor oil spill location even in open area by using newly developed remote sensing instruments. Sometimes, oil spill surveillance is done by using simple video photography[14]. The most common method of

an oil spill location is by using unnamed aerial vehicles (UAV'S) like drones. Radar technique and Micro wave technique are commonly used in Remote Sensing for detection of oil spill. Table 03 show some satellite based sensor used for oil spill detection.

Table 03 : Current and future used satellite Born Sensor

SATELLITE	OPERATION YEAR	OWNER	PROPERTIES
SEASAT	1978	NASA	L-Band, HH-pol
ALMAZ-I	1991-1992	Russian Space	S-band , HH-pol
ERS-1	1991-1996	Agency	C-band , VV-pol
ERS-2	1995-Till	ESA	C-band , VV-pol
RADARSAT-1	1995-Till	ESA	C-band , HH-pol
ENVISAT	2002-Till	CSA	C-band , HH, VV pol

As per researchers observation, 48 % of oil pollution in the sea is because of the fuels and 29 % of petroleum oil. Remaining is because of tanker accidents and operative discharges ships. Active microwave SAR sensors are used for capturing two dimensional images. Most commonly used providers for satellite images oil spill monitoring are like RADARSAT-1 and ENVISAT. Dark spots are observed in satellite images because oil spill dampen the Bragg waves on the ocean surface which indicates location of oil spill. Different processes like evaporation, emulsification and dispersion plays important role in oil spill detection technology. Lighter component of oil spill will evaporate to the atmosphere. The factors affecting on rate of evaporation include type of slick, thickness of slick, speed of wind, sea water temperature etc.

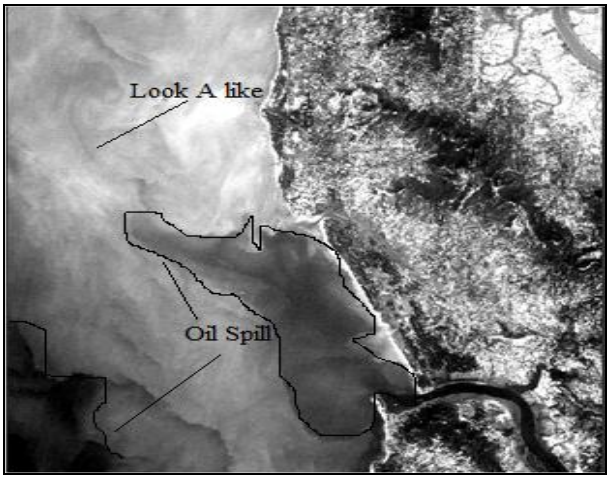

Figure 12: Satellite Image shows oil spill

Figure 12 shows image taken from ERS-2 Satellite on 3rd October, 2010 at Alibaug Beach. The biggest problem in detection of location of oil spill is to differentiate between oil slicks and look a likes spot. Because oil slicks may include all oil related surface films consisting oil rigs whereas look alike contains natural films of grease ice. By using Remote Sensing technologies it is possible to differentiate between oil slicks and look alike. In Figure 12, oil slicks are indicated by dark black spots and for clarification it is marked by black border lines.

IX. CLEAN UP SYSTEM

To avoid marine tar pollution at Alibaug beaches, one clean up assessment technique was carried out at Revdanda Beach. A team of seven to eight members were formed which is known as oil spill response team. Team cleans all the affected areas by manually or with the help of clean up vehicles. In beaches of Alibaug region clean up system was organized by Maritime board(Mumbai), JSW Company and Revdanda Villager This cleaning process is shown in Figure 13 and Figure 14.

Figure 13: Clean up System

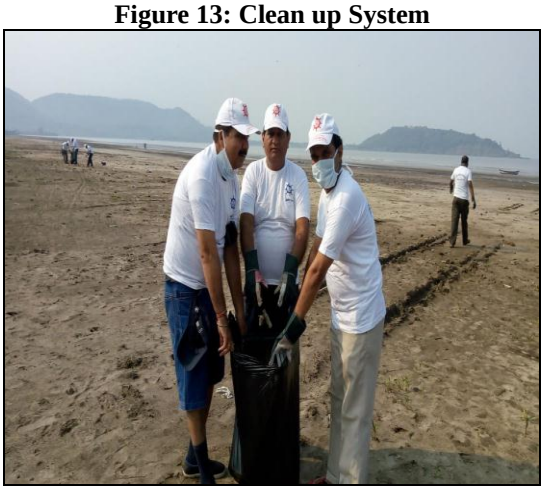

Figure 14: Clean up System

X. CONTROL MEASURES

Following control measures are required to adopt for minimizing adverse effects of Pollution:

1. Manual method should be adopted to remove tar balls having size 10 cm diameter or more.
2. Biological techniques should used to remove tar balls which contain hydrocarbon material.
3. Government authorities should enforced strict regulation for activities like washing and maintenance of ships, transportation of oil through sea at important beaches.
4. Coastal zone regulatory authorities should arrange Public Awareness Program with the help of social media like Television, press, advertisement etc.

XI. CONCLUSION

From testing like penetration test, conclusion is made that , it is possible to replace bitumen by marine tar which helpful to avoid many adverse effect produced by tar balls. Then, from flash and fire point test , it is said that replacement of bitumen by marine tar residue is possible even in high temperature region. From use of Remote Sensing software's conclusion is that the source of marine pollution is basically accidental leakages of oil from ships. Remote sensing images contain dark centered spot which means oil leakage is from distinct place. Reason of oil spill like accidental discharge from ship, offshore drilling operation was also studied. Last from clean up assessment system team cleans the beaches to some extent but this method is laborious. The district government should create strict regulations for activities like washing ships at designated ports and harbor to minimize effect of marine pollution.

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