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Estimation of time of travel for oil spillage in coastal region

[1] Monica C. Dhoka, [2] Vilas B. Joshi, [3] Vasant V. Vaze, [4] Priya P. Hirawe

[1] Reeasrch scholar of Department of Civil, Bharati Vidyapeeth Deemed University College of Engineering, Pune, Maharashtra, India-411043.

[2, 3] Visiting Professor of Department of Civil, Bharati Vidyapeeth Deemed University College of Engineering, Pune, Maharashtra, India-411043.

[4] Assistant Professor of Department of Civil, Bharati Vidyapeeth Deemed University College of Engineering, Pune, Maharashtra, India -411043.

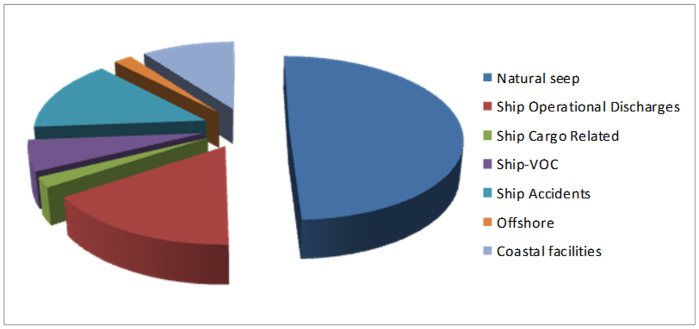
Abstract

About 70% of an earth is covered with sea which is being threatened by coastal & offshore activities for pollution such as oil exploration, exploitation, transportation and collisions of oil tankers are responsible for leakages causing oil spills. It leads to depletion of aesthetic and intrinsic value of marine ecosystem as well as wastage of millions tonnes of oil. Many scientist have tried to predict the possible transport of the oil spill and its effect on shoreline based on the mathematical model studies and various other parameters, however each of these require large data input. Review of the literature was made. Studies of a case study were made and attempt has been made to develop a simplistic approach to determine the time of travel of the oil spill from the location of the spill to reach the shoreline. Assessment is done by comparison of analytical results with available satellite data. These results are validated by conducting flume studies by injecting floating spilled material. From the present study, it was revealed that wind, waves, currents and tides are primary forces while density and viscosity are relatively secondary parameters governing dispersion. In this paper, efforts have been made to assess time of travel of oil slick from the point of spill to nearest shoreline likely to be affected. Suggestions are offered to analyse the complexity of marine environment and to predict dispersion before reaching to shore within few hours.

Keywords: assessment; oil spill; hypothesis; validation

Introduction

All over the world, 'Pollution' is the most harmful disaster causing direct-indirect ill-effects on human being and environmental ecosystem in general and human being in particular among various types of pollution, coastal pollution is the most dangerous which is damaging marine ecosystem severely. Industrial and residential waste, land run-off, wind-blown debris, thermal and chemical pollutants, import-exports business on coastal areas, exploration and transportation of crude oil and fuels, tourism etc. are various factors which are responsible for coastal pollution [3]. Oil pollution is the most responsible for degradation of marine ecosystem. India is one of the oil importing country. During 1982-2011, out of 76 accidents 70 % oil spillages took place on west coast of India and approximately 113000 million tonnes of oil has spilled [5]. The coastal region of Mumbai including creek, harbour and steep slopes are always at high risk of oil spills. Due to oil spills, millions tons of oil is wasted and dispersed on surface causing anaesthetic environment. Sources of oil pollution are presented in pie chart 1 below. It is observed that 13-14% oil spill occurs due to ship and tanker accidents. The most important phenomenon to be focussed is dispersion of oil slick which has to be attended and controlled before reaching at shore. As dispersion gives visibility to oil pollution and is responsible for depletion of marine ecosystem, hence it should be examined by comparison of analytical with satellite imageries and conforming results with experimental studies. The present study attempts validation of a event occurred off Mumbai.



Pie chart 1: sources of oil pollution

MV RAK carrier: A cargo ship named MV RAK carrier sank on 4th August 2011 at geographical position is 18 º 46'29"N, 72 º 29'19" E nearly at 20 nautical miles from coast of Mumbai [1]. Approximately 350 tonnes of oil was spilled after skiing in the Arabian Sea. Oil spillage was reported on 6th August 2011. Ship was transporting Fuel oil, Diesel and coal from Indonesia to Gujarat, India. The spilled oil was travelled to different shores on west coast of India. Signs of oil slicks affected beaches at Juhu, Aksa, Madh, Marve, Gorai, Alibaug as shown in fig1. Accident occurred in SW monsoon hence sea was not in calm condition resulted in more dispersion by currents and tides. The mangroves and sediment was affected in forms of tar balls, oil pools as well as flora-fauna were also affected along the coastline.

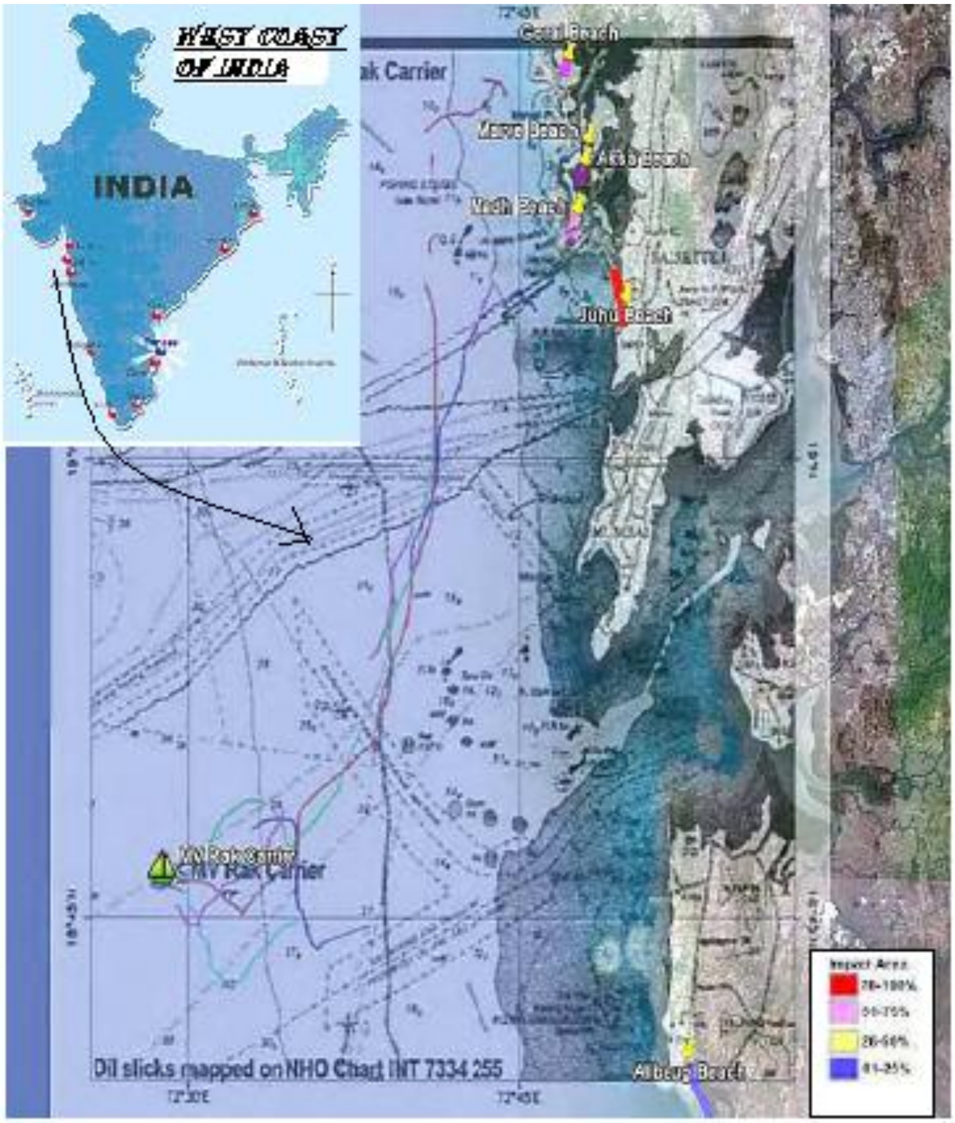


Fig 1: Satellite Image showing oil slicks through sea striking on shore with duration

Material and methodology

Methodology used for analysis to assess the dispersion phenomenon includes data for executing estimation. Weather data of coastal water of Arabian Sea was bought from IMD, Pune. Data for analytical method was validated with ship observed data (IMD) and wave rider buoy data obtained from NCRS website [6]. Values of wave height, wave period and time duration are confirmed from SMB (*Sverdrup-Munk-Bretschneider*) Curve from Shore Protection Manual. The necessary details like location of spill, quantity, date and time of the spill were analysed from ENVISAT ASAR and RADARSAT satellite images captured by INCOIS. Details of signs of oil slick and location were collected from EIA report by NEERI.

Analytical method

Dispersion is a phenomenon in a coastal region is governed by wave form, attenuation & shoaling considering the effect of change in depth or slope. However, in this peculiar site bottom slopes, changes in depth between point of injection & breaker indicate very mild slopes hence effect of wave form, attenuation are neglected since oil dispersion is a surface phenomenon. Linear wave theory covers surface phenomenon which includes estimations of wave celerity, times of travel and mass transport velocity. Analytical method is the most convenient which provides a rough prediction of movements of an oil slick so that to avoid the damages. Depths at various points have been observed from nautical chart on which contours have been shown in drawing.

By using basic inputs of waves obtained from IMD data further estimation of wave celerity, wave length, breaking wave height, time of travel of trail of oil spill from deep water, intermediate to shallow water and at last on beach at Juhu, Madh, Marve, Aksa, Gorai, Alibaug were carried out. Impact of dispersion spread was seen to be more in shallow depths. Minimum time of travel is calculated for different strands at different locations on different days, so that contingency preparation can be done for future events from past events. Table 1 shows estimated values of all parameters.

Table 1: Estimated values of parameters

Date	T(sec)	Cavg (m/s)	Distance Travelled (m)	Time of travel	Hb(m)	Distance after breaking upto shore (m)
9th August	6	8.71	$81*10^3$	18hr 14min	0.78	750
10th Aug [I]	7	9.087	$91.5*10^3$	16hr 18min 21sec	1.56	1500
10th Aug [II]	7	6.773	$27*10^3$	8hr 36min 28sec	1.56	1200
11th Aug [I]	7	8.4	$66*10^3$	13hr 43min	1.56	1500
11th Aug [II]	7	7.56	$39*10^3$	10hr 31min 52sec	1.95	750
13th Aug [I]	8	9.155	$67.5*10^3$	14hr 24min 30sec	1.56	1800
13th Aug [I]	8	6.72	$24*10^3$	8hr 47min 40sec	1.56	2250

Experimental study

Experimental study is done as a supportive to understand mass transportation i.e., dispersion with effect of density and viscosity of material dispersed on surface which represents linear wave theory. Experimental studies on flume were done in Bharati Vidyapeeth (Deemed university), Pune. Rectangular flume which is tilting flume was adjusted to straight flat bed. Flume was 10m long, 30 cm wide and 45 cm deep. Material such as diesel, engine oil, petrol, blue clothing dye were released in flume for measuring time of travel up to certain point with varying velocity in flume and materials. Literature studies revealed that previous investigators above not considered effect of the physical properties like density, Specific gravity and viscosity of the effluent. Properties such as density, viscosity and specific gravity for the effluent studied are mentioned in table 2 with time of travel for minimum velocity of 10.42cm/sec.

Fig 2: Dispersed oil and diffused dye in flume

Table 2: Property and time of travel in flume study

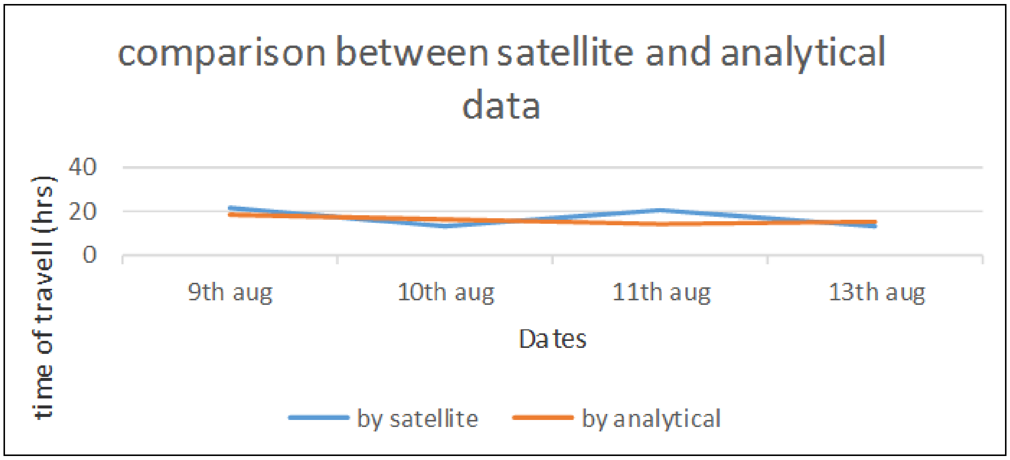
Material	Density (kg/m^3)	Viscosity (mm^2/s)	Specific Gravity	Time of Travel for length 450cm (sec) @ velocity 10.42cm/s
Diesel	820-890	3	0.82-0.89	26.99
Engine oil	890-900	10	0.89-0.90	31.44
Petrol	737.22	2-4.1	0.737	22.79
Clothing Dye	1199-1450	0.35	1.19-1.450	35.16

Results and Discussions

1. **Wave data:** Based on the input date obtained from IMD, Wave Rider Buoy and SPM data indicates that representative values of wave height and wave period are H= 2-3m and t= 6-7 seconds.

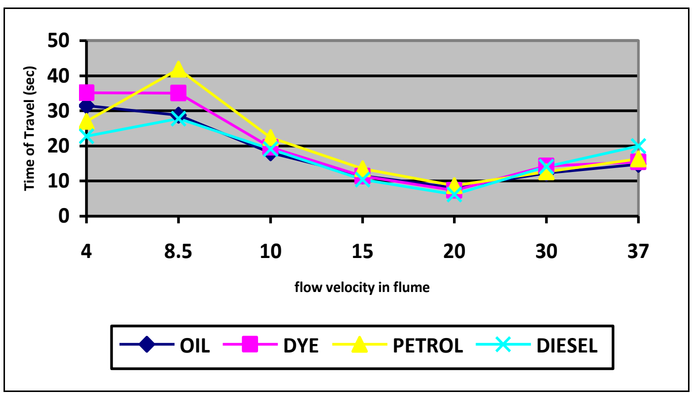
2. **Comparison of times of travel:** Graph 1 indicates comparison between satellite observed data (figure 1) and analytically computed data i.e., Time of Travel is the time taken by the oil slick from the location of the incident to reach shore from deep water from a discharge point of spill. It gives expected variation between both durations.

3. **Results observed from experimental study:** Times of travel for different magnitude of wave induced currents are compared with times based on satellite imageries plotted in graph 1 shows expected variations.



Graph 1: Comparison of the times of travel based on Satellite imageries and analytical estimation

4. **Effect of density and viscosity:** In flume study, it is observed that variation of times of travel for varying discharges not only depend on wind and waves but also affected by their own properties of density and viscosity. In graph 2, it can be clearly seen that material approximately with similar density shows variation due to viscosity.



Graph 2: Variation of times of travel with varying water flow in flume

Conclusion

From above discussions, it is concluded that much of the discrepancy between estimated and observed as well as predicted wave data in random and statistical summaries of observations and predicted values will agree much better than individual observations. Efforts have been made to apply linear wave theory to assess dispersion phenomenon. Oil spilled on surface of water was drifted due to currents as well as density of that specific material. Where densities of two different materials were approximately same in that case viscosity was seen to be influence the mass transport process. Material having more density than water diffuses in water as potassium permanganate or blue dye while material having low density, dispersed only on the surface. Attempts have been made to predict the rough estimate of times of travel towards coast. Remedies could be suggested quickly if accident is reported immediately within few hours before coming to the shore and further disaster would be avoided. Availability of detailed data can lead to advanced study of dispersion by numerical modelling

Limitations

Mostly coastal data is confidential and hence difficult to obtain easily. Laboratory studies restrict real time data as compared to field. Satellites do not provide continuous real-time images of the complete movement of oil slick from the point of spill to the shore and has to be analysed using the available imageries. In view of the complexity of the processes under coastal environment, lots of assumptions have to be made. This may lead to deviation in actual time of travel to some extent. Attempt has been made to provide more simplistic approach for estimation of travel time in order to attend and arrest the effluent before it reaches the shore and thereby protect shore and ecosystem from possible pollution effect.

References

1. Environmental Assessment of Mumbai Oil Spill from MV RAK Carrier National Environmental Engineering Research Institute (NEERI).
2. Corrêa MA, Yassuda E. Tracer dispersion study: Diffusion coefficient and modelling results. I*nternational Symposium on Outfall Systems, Mar del Plata, Argentina*, 2011, 15-18
3. Kapil S. Sukhdhane, Priya E. R., Shailendra M. Raut, Teena Jayakumar. August Status of oil pollution in Indian Coastal Waters *Fishing Chimes* 2013; 33(5).
4. Vaidyaraman PP, Parchure TM, Vaze VV, Ghosh LK. A few case studies related to marine pollution problems.
5. Navneet Rai, Pandey IP, Kamal Joshi. Impacts and Management of Oil Spill pollution along the Indian coastal areas, 2011. *http://www.hgpub.com/index.php/jirter*
6. http://odis.incois.gov.in/index.php/in-situ-data/wave-rider-buoy/data-access