



NATIONAL INSTITUTE OF OCEANOGRAPHY

(Council of Scientific & Industrial Research)

DONA PAULA. GOA-403 004. INDIA

M. V. SEA TRANSPORTER OIL SPILL AND ITS ENVIRONMENTAL IMPACT ASSESSMENT



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Dr. E. DESA

Drs. L. U. JOSHI & A. H. PARULEKAR
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**Drs. S. Y. S. SINGBAL, S. P. FONDEKAR
& Z. A. ANSARI**

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CONFIDENTIAL

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PARTICIPANTS

Dr. S.Y.S. Singbal

Dr. S.P. Fondekar

Ms. C. D'Silva

Dr. K. Sawkar

Mr. S.S. Sawant

Mr. S.A. Karim

Dr. Z.A. Ansari

Dr. S.G.P. Matondkar

Mr. B.S. Ingole

Dr. X.N. Verlencar

Mr. R.A. Sreepada

Mr. N.P. Mhamal

Ms. M.C. Saldana

EXECUTIVE SUMMARY

- a) On 5 June 1994, ore carrier M.V. Sea Transporter, was drifted to Siquerim-Goa coast from Mormugao harbour in the squall that hit the Goa coast and grounded on the rocks, a few metres from the Siquerim beach. The ship carried about 1000 tonnes of residual oil.
- b) On 13 June 1994, Coast Guard along with Singapore-base salvage firm SEMCO, began oil-flushing-out operation.
- c) On 2 July 1994, due to gusty winds, a crack was developed on the starboard side, thus spilling oil from the ship. The amount of oil spilled was estimated around 2 tonnes.
- d) A team of scientists from National Institute of Oceanography (NIO) Goa, carried out a survey in the spill area to study the eventual environmental impact.

- e) Observations were made on oil-slicks, tar residues, petroleum hydrocarbons in water and beach sand, bacteria, phytoplankton, chlorophyll a zooplankton and benthic meiofauna.
- f) Several oil patches either treated or untreated were observed in the spill area of Sinqerim due to leakage of oil from the ship.
- g) Dissolved petroleum hydrocarbons were higher by almost 3 orders of magnitude or around 1000 times as compared to background levels in the same area. However, there was a gradual decrease in the DPH concentrations in the later stage.
- h) Observations on bacteria showed partly degradation of oil in water and in beach sand. Low percentage of sensitive species of zooplanktonic copepods and amphipods highlights the adverse effects of oil on marine biota.

1. BACKGROUND

On 5 June 1994, ore carrier M.V. Sea Transporter, was drifted to Sinqerim-Goa coast from Mormugoa harbour in the squall that hit the Goa coast and grounded on the rocks, a few metres away from the Sinqerim beach. The ship carried about 1000 tonnes of residual oil. Almost a week after, on 13 June 1994, Coast Guard along with Singapore-base salvage firm SEMCO, began oil-flushing-out operation.

On 2 July 1994, due to gusty winds, a crack was developed on the starboard side. This resulted in spilling the oil from the ship. Initially, the amount of oil spilled was very little. But as the crack widened, the spilling had increased to almost 25-30 litres/hour. The amount of oil spilled was estimated around 2 tonnes. In all, about 800 litres of dispersant were used for the dispersion of the oil. Oil slick had stretched to more than one kilometer between Sinqerim and Calangute and was clearly visible around the ship and close to the beach.

A team of scientists from National Institute of Oceanography (NIO) Goa, carried out a survey in the spill area to study the eventual environmental impact. The observations were carried out in the spill area and adjacent regions between 4 and 29 July 1994.

2. OIL ON THE SEA

Petroleum, when spilled into the sea, is subjected to a series of diverse processes, the first is its dispersion in the marine environment; the second is its ageing and finally the changes it undergoes in its physical and chemical characteristics.

Immediately after a spill, the lighter fractions of oil evaporate. In the warm waters of the equatorial and tropical oceans, it has been observed that this evaporation will remove as much as 40% of the spill during the first 24 hours. Oil will also be oxidised by consumption of dissolved oxygen. Microbial degradation will account for 2g of oil per square metre per day. Around 1% of the spilled oil will be dissolved or dispersed in water. In addition, photo-oxidation by

solar radiation will also degrade a part of the oil. Thus, it can be expected that around 45-50% of any oil spill will be removed during the first 24 hours in the warm zone of the ocean. The heavier fractions of the spill will form drifting patches being split up by the prevailing winds and currents. These patches will ultimately end up as floating tar particles which finally, will either sink to the bottom or be washed ashore on beaches.

3 . CHEMICAL DISPERSION

Clearly oil does not remain permanently on the sea surface. It may disperse into the water column either completely or partially under the action of natural forces and/or it may come to the shore. Dispersants are simply a means of increasing the natural dispersion rate so that sufficient dispersion will have occurred to remove the oil from the sea surface before it reaches the shore.

Dispersants or emulsifiers are liquids, the bases of which are organic solvents and surface-active agents (surfactants). The purpose of all the dispersants in use is quick elimination of oil on the surface by breaking an oil-slick into very fine droplets (less than 100 microns in diameter) which are rapidly distributed throughout the water volume because of the natural water movement. The third component of the dispersant is a stabilizer for making the emulsion stable.

All dispersants are likely to be toxic to marine life and as such direct application of the dispersants may prove fatal to most marine organisms. Hence, the dispersants to be used, must be carefully chosen with particular reference to their toxicity and applied with caution.

4. WORK PLAN

Observations in the spill area of Siquerim and adjacent regions - Candolim, Calangute and Vagator were commenced on 4 July 1994 soon after the oil spill and continued till 29 July 1994. The baseline data was also

collected on 20 June 1994 prior to spill. The sampling locations are presented in Fig. 1.

Observations were carried out on oil sightings, tar residues, dissolved petroleum hydrocarbons and petroleum hydrocarbons in beach sand. Samples were also analysed for bacteria, phytoplankton, chlorophyll a, zooplankton and benthic meiofauna.

5. OBSERVATIONS

Oil sightings:

Observations on oil sightings, showed several signs of oil patches either treated or untreated in the spill area when oil spill was actually in progress. The first patches of oil spill in the form of thin film, were spotted off Siquerim and Baga after the ship developed a crack on the starboard side. Faint patches of oil were also noticed on the Siquerim beach.

Aerial survey conducted along the coast, showed that small patches of oil sheen appeared in the sea and were drifting more towards the north and to some extent southwards. These patches of oil sheen continued to

exist at Sinqerim even after a week from the oil spill incident. Observations carried out later on showed no signs of oil patches.

Tar residues :

Tar residues could be collected at Sinqerim beach as well as adjacent beaches - Candolim, Calangute and Vagator. Maximum concentrations of tar were observed at Sinqerim on 12 July 1994 (10 - 1700 g/m²). These concentrations were quite high as compared to those in adjacent regions (0.24 - 33 g/m²) and mainly resulted from the present oil spill.

After the first 24 hours, owing to sea state and high temperature, water-in-oil mousse may be formed due to prevailing wind which will adsorb on to the surface of any suspended particle to form tar residues or tar balls. These tar balls either sink to the seabed or get suspended by the buoyancy of its size in an intermediate water mass and flow out. The remaining tar balls will, ultimately be washed ashore on the nearby beaches.

Petroleum hydrocarbons:

Water - In general, dissolved petroleum hydrocarbon (DPH) concentrations at Sinqerim ranged between 0.019 and 11.74 mg/1, (av. 3.38 mg/1) excluding the higher values (56.06 and 836.84 mg/1). This data is presented in Table 1. Higher values were obtained on 5 July 1994 when oil continued to spill in the marine environment. DPH concentrations observed in adjacent regions - Candolim, Calangute and Vagator were between 0.003 and 0.230 mg/1.

The observed DPH concentrations (0.019 - 11.74 mg/1) at Sinqerim were higher by almost 3 orders of magnitude or around 1000 times as compared to background levels of DPH (av. 0.014 mg/1) in the same area prior to oil spill. However, observations carried out later on 28 July 1994 showed a gradual decrease in DPH concentrations.

Beach sand - Petroleum hydrocarbons in beach sand at Sinqerim also showed higher values ranging between 1.25 and 6622 µg/g). These values were quite high as compared to those at Candolim, Calangute and Vagator (0.16 - 0.41 µg/g).

The distribution of petroleum hydrocarbons in surface sediments, particularly in the 0 - 20 cm segment, is of importance to studies of oil contamination in the marine environment. About 56% of spilled oil becomes adsorbed to bottom sediment where oxidation may take several years. Thus, the degree of oil pollution in the marine environment may be more accurately assessed by measuring oil in sediments rather than in the overlying water column.

Bacteria :

Total viable bacteria and oil oxidising bacteria were counted on oil agar and marine agar plates from 3 stations (Fig.1) for a period of 4 weeks during July 1994. The total viable counts (TVC) remained uniform throughout the study period, ranging from 6.0×10^4 - 7.7×10^4 CFU/ml. This may be partly due to the turbulent sea conditions, prevailing during southwest monsoon season. The oil oxidising bacteria (OOB) were present in all the samples with varying proportion of TVC. Initially it was 1.2×10^3 CFU/ml, reaching to 1.0×10^4 CFU/ml during peak oil pollution and decreased to 1.0×10^3 CFU/ml during last week of July. This trend was

seen in all the samples collected from 3 sites. In conclusion, it may be said that increase in oil substrate enhanced OOB population, which is capable of partly degrading oil in water and in beach sand.

Phytoplankton & Chlorophyll a:

Phytoplankton biomass in terms of chl-a ranged from 0.6 to 5 mg m⁻³ during the sampling period from early July till the end of July 1994. Lower chl-a values were recorded at Sinqerim and Candolim beach on 5/7/94 when the oil spill was actually in progress. However, the values increased subsequently which could be as a result of spraying of dispersants. The dispersants are generally rich in the phosphates and could help in blooming of particular phytoplankton species.

The chl-a at Calangute beach however remained almost steady during the entire sampling period. Phaeophytin which is the degradation product of chla ranged from 0 to 1 mgm⁻³. The phaeophytin did not show any measurable changes.

Chl-a values as compared to the earlier data for corresponding months of 1981-82 at Sinqerim-Candolim beach showed that there was a general increase in chl-a

values during present investigation. Phytoplankton cell counts showed low values on 5/7/94 at Sinqerim. The values reduced further during the succeeding days. Towards the end of July, the population density showed an increasing trend. The dominant species was Coscinodiscus.

Zooplankton:

Zooplankton analysis showed that the fauna were dominated by copepods while other groups were cirripede, foraminifers, polycchaetes, gastropod and bivalves. Copepods which are rather most sensitive to petroleum hydrocarbons in seawater were low at Sinqerim as compared to Calangute and Candolim. Amphipoda another sensitive taxa were almost absent.

However, the low percentage prevalence of copepod during the first 4 days after the treatment of spilled oil with dispersant suggests, the adverse effects on zooplankton communities.

Benthic meiofauna :

Meiofaunal samples were collected from the three locations along the Sinqerim - Candolim - Calangute

beach at high and mid-tide water mark during July 1994, on 5 dates.

Meiofauna was comprised of common taxa such as Nematoda, Harpacticoida, Turbellaria and Polychaeta. As revealed from the first two weeks sampling, the meiofauna density at Sinqerim ranged between 18 to 262 per 10cm^2 at the mid-tide level. This station (stn. 1) along the Sinqerim beach was in close vicinity of M.V. Sea Transporter.

The meiofaunal population density at Candolim and Calangute beach ranged between 39 to 479 and 124 to 338 individuals per 10cm^2 respectively. When compared with the earlier baseline data, the meiofauna at Sinqerim beach showed decreasing trend, indicating the probable adverse effects of oil and dispersants on the beach fauna. The population density at Candolim and Calangute beach however, were comparable with the earlier data.

6 . CONCLUSIONS

- i) The estimated volume of spilled oil is around 2 tonnes, part of which should have been evaporated. The volume of the oil was further reduced by

chemical dispersant treatment, as a result of which, the oil is partially dispersed into the water column.

- ii) The winds, currents and swells broke the remaining part of the spill into several small patches. These patches ultimately end up as floating tar balls which finally, either sink to the bottom or be washed ashore on the beaches.
- iii) Dissolved petroleum hydrocarbons in the spill area were quite high in the initial stages, around 1000 times as compared to those background levels in the spill area prior to oil spill. However, later observations showed a decreasing trend in concentrations.
- iv) Increase in number of oil oxidizing bacterial (OOB) flora capable of degrading petroleum hydrocarbon in marine environment, reflects on more than normal availability of oil substrate. This is further authenticated from the gradual decline and normalization of OOB population with reduction in the volume of oil in the environment.
- v) Substantial increase in phytoplankton biomass, in the post-oil dispersant treatment period, suggests

the enrichment of phosphate from dispersant which boosted the production.

vi) Chlorophyll-a content showed a general decrease when compared with baseline values of 1981-82. Was it an after-effect of oil spill or dispersant treatment and/or both?

vii) Low percentage prevalence of otherwise dominant but environmentally most sensitive species of zooplanktonic copepods and amphipods especially during the peak period of oil spill, highlights the adverse effects of oil on marine biota.

viii) Detrimental effects of oil and dispersant, singly or jointly, on the sediment dwelling meiofauna, was greatly manifested, as seen from decreasing trend in population density at Siquerim beach as compared to baseline data for corresponding period of earlier years.

TABLE 1 : Data on dissolved petroleum hydrocarbons (DPH)
in oil spill region and adjacent areas.
(DPH in mg/l)

Date	STATIONS				
	Singerim (oil spill area)		Candolim	Calangute	Vagator
	1	2	3	4	5
<hr/>					
<u>Before oil spill</u>					
20.6.94	0.017	0.011		0.006	0.005
<u>After oil spill</u>					
4.7.94	0.163	0.019		0.016	0.008
5.7.94	56.068	836.848	0.078	0.023	
7.7.94	1.160	2.136		0.155	
12.7.94	11.731	11.740	0.230	0.026	0.015
28.7.94	0.036	0.059	0.007	0.023	0.003
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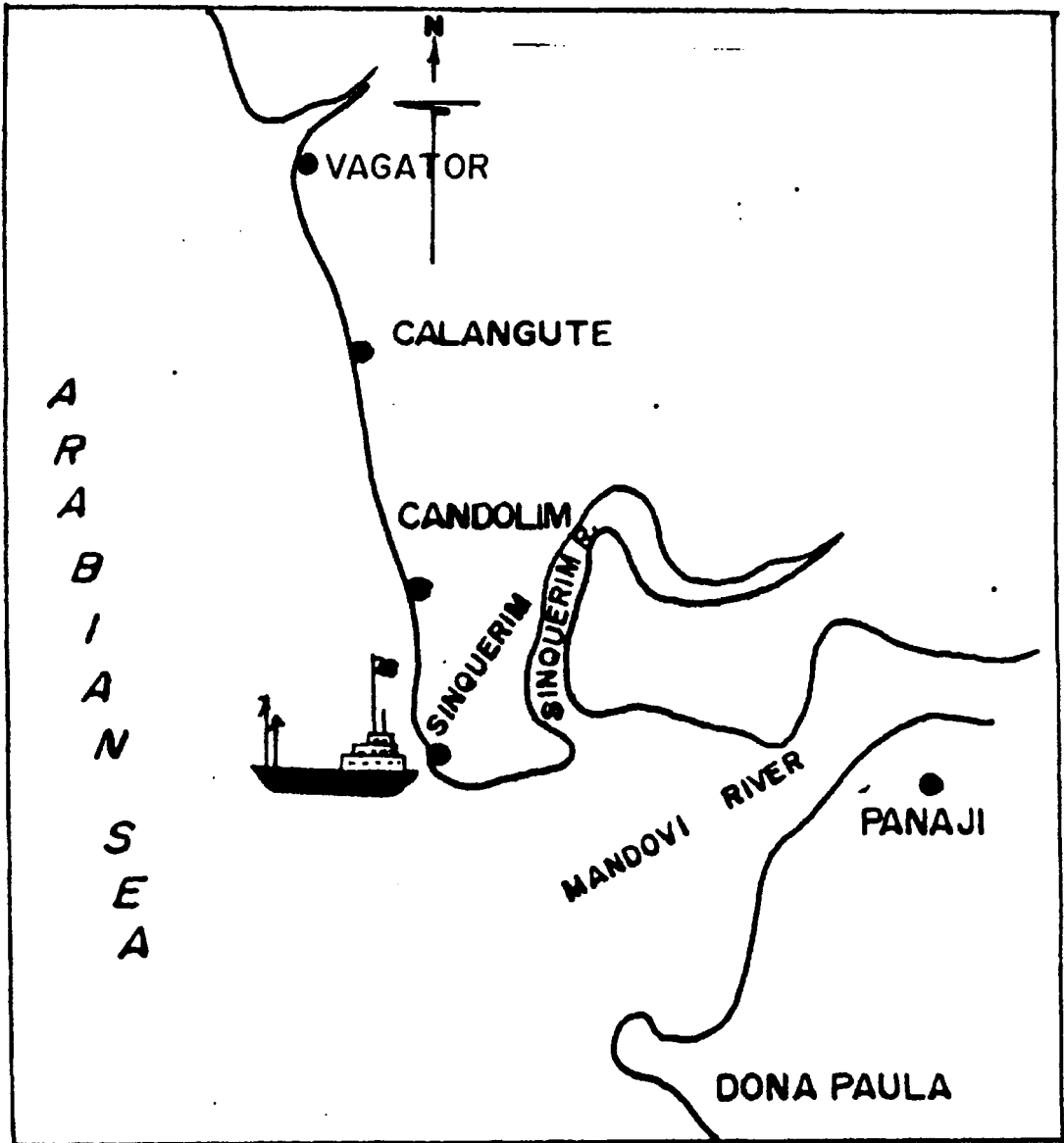
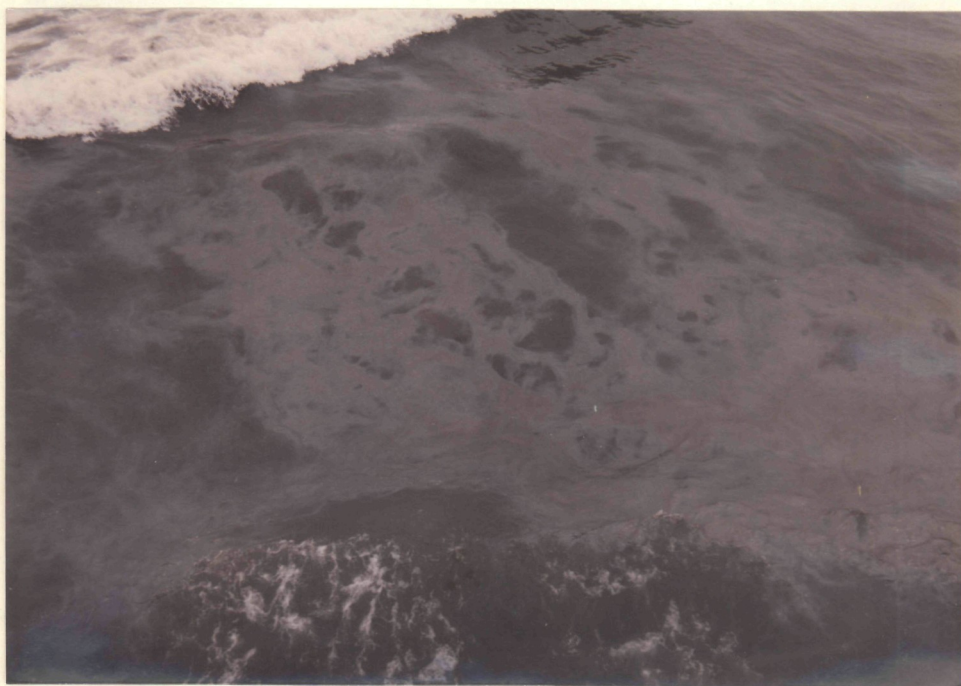


Fig. 1 Location of the Sampling Stations,



1. Oil patch drifting towards the shoreline - Siquerim



2. Oil seen near the shore - Siquerim



3. Oil patches clearly visible on the shore - Siquerim



4. Oil contaminated beach - Siquerim