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EFFECT OF "TASMAN SPIRIT" OIL SPILL ON MARINE PLANTS IN THE COASTAL AREA OF KARACHI

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ABSTRACT

The present paper deals with the impact of "Tasman Spirit" oil spill on marine primary producers which occurred near Karachi Harbour on July, 27th, 2003. One year long study in the affected area revealed that phytoplanktons were seriously affected by oil spill but not so much seaweeds and mangroves. Very low species diversity of phytoplankton was observed as compared to previous observations in the same and adjacent areas but the standing crop (phytoplankton abundance) was not affected. Large size species dominated over the smaller ones indicating adjustment to presence of low density oil on the surface of water. Centric diatoms out numbered the pennate forms and armoured dinoflagellates the naked forms. The seaweeds were less affected. The attached forms on the buoys and floating forms survived the spill. However, those growing attached to small rocky patches on the beach died due to deposition of thick layer of crude oil, but later recovered soon after the oil spill was over along with barnacles. The mangroves do not grow in the affected area nor did the oil reach the adjacent mangrove stands, therefore, its effect on them could not be studied. However, the mangrove propagules and seedlings drifted in the area were all damaged and killed, thereby affecting the benthic food chain ad also the reproductive potential of the mangroves of the adjacent areas.

Key-words: Tasman Spirit, oil spill, Karachi coast, marine plants

INTRODUCTION

On July 27th, 2003 a Greek oil tanker "Tasman Spirit'ran aground near the Karachi harbour and its oil tanks leaked causing the worst oil spill in the history of Pakistan. The tanker was carrying 67,500 tons of light crude Iranian oil and as much as 30,000 tons got leaked and spread into the surrounding waters and the shore. Fortunately the prevailing wind direction was such that the spilled oil did not spread over the shelf but gathered on a 12 km stretch of Clifton beach between Shireen Jinnah Colony and to the west of the Village restaurant. The beach was covered with thick black crude oil for a few weeks littered with carcasses of a large variety of dead marine organisms. These included benthic, planktonic and nektonic individuals which most probably died of suffocation as their entire bodies were covered with a thick coating of oil. A thin film of oil also covered the surface of the seawater adjacent to the affected area. The oil gradually disappeared after several weeks of mechanical and chemical cleaning and treatment operations both on the beach and the water (Beg, 2003). The present study is a preliminary assessment of the oil slick on the primary producers of the affected area including phytoplankton, seaweeds and mangroves.

MATERIALS AND METHODS

Samples of seawater and marine plants including phytoplankton, seaweeds and mangroves were collected from the affected site near the mouth of the Manora Channel (Karachi Harbour) adjacent to Clifton beach (Saifullah *et al*., 2002). Phytoplankton samples were collected by horizontal net hauls of 50 µm mesh size in vicinity of Tasman Spirit. Quantitative samples were obtained by taking water samples in 1 litre flask. Both samples were fixed immediately in 4% formalin. The species were identified in the laboratory using a research light microscope and quantitative estimates were made using a Sedgwick Rafter cell. An aliquot of 1 ml was taken for the estimation of both actual and relative abundance of different groups and species of phytoplankton. Floating, drift and attached seaweeds were collected and also fixed in 4% formalin. Mangroves do not grow on Clifton beach because it is sandy, however, the propagules and uprooted seedlings drifted from adjacent areas were taken into account. The mangrove stands in the neighbourhood of the affected site were also visited to see if the oil has reached there and caused some adverse effects. Temperature and salinity of seawater were measured using a thermometer and a refractometer respectively.

RESULTS AND DISCUSSION

The temperature of sweater ranged between 20 ºC and 30 ºC during the year of study with low values in winter and high in summer (Table 1). The salinity did not show that much variation in values and ranged between 34 psu and 38 psu only. No seasonal trend was noticed like temperature but the values seem to be affected by intermittent flow of the Lyari river into the harbour.

In all 60 species and 31 genera of phytoplankton were recorded in the waters of the affected area around the grounded tanker ‘Tasman Spirit’ (Table 2)). The diatoms were the most diverse group with 35 species followed by dinoflageallates (22 spp.), *Cyanobacteria* (2 spp.) and coccolithophores (1 sp.). The total number of species recorded appears to be less than described earlier from the same locality and also from adjacent areas. Saifullah and Moazzam (1978) reported 101 species of centric diatoms whereas Hassan and Saifullah (1971, 1972, 1974) and Saifullah and Hassan (1973, 1973a) reported more than 40 species of 4 genera of dinoflagellates from the Karachi harbour area. The diversity of phytoplankton on the adjacent shelf is even far more higher. Kuzmenko *et al*. (1975) recorded 344 species of phytoplankton from North Arabian Sea bordering Pakistan, that is about six times more than in the present study. Chaghtai and Saifullah (1988) also described 47 species of a single species of dinoflagellate *Ceratium.* The observed very poor diversity of species in the area may, therefore, be attributed to the deleterious effect of oil slick.

Table 1. Temperature and salinity values during the period of study.

Date	Temperature oC	Salinity psu
24.8.03	29	35
3.9.03	29	36
27.9.03	32	36
14.10.03	28	38
12.11.03	26	34
12.12.03	22	34
24.1.04	20	37
22.2.04	22	38
27.3.04	22	35
7.4.04	25	35
24.5.04	31	35
27.6.04	30	34
6.7.04	29	35

Table 2. Species composition of phytoplanktons.

Phylum: BACILLARIOPHYTA (DIATOMS)
Class: Bacillariophyceae
Order: Centrales
Family: Asterolampracea
1. *Biddulphia mobiliensis*
2. *B.* sp.2.
3..*Eucampia Zoodiacus*

Chaetoceraceae
4. *Bacteriastrum* sp.
5. *Chaetoceras brevis*
6. *C.decipiens*
7. *C. laciniosum*

Coscinodiscaceae
8. *Coscinodiscus granii*
9. *C. centralis*

Eupodiscaceae
10. *Triceratium favus*

Hemidiscaceae
11. *Hemidiscus cuneiformis*

Lithodesmaceae
12. *Ditylum brightwellii*

Melosiraceae
13. *Stephanopyxis palmeriana*
14. *S. turris*

Rhizosoleniacea
15. *Guinardia flaccida*
16. *Rhizosolenia accuminata*
17. *R. alata*
18. *R. hebetata*
19. *R. imbricata*
20. *R. robusta*
21. *R. styliformis*

Thalassiosiraceae
22.*Cyclotella* sp.
23. *Planktoniella sol*

Order: Pennales
Family: Fragilariaceae
24. *Asterionella* sp.
25. *Grammatophora* sp.
26. *Licmophora*
27. *Synedra undulata*
28**.** *Thalassioema nitzschioides*
29. *Thalassiothrix delicatula*
30. *T. frauenfeldii*
31. *T. longissima*
Naviculaceae
32. *Gyrosigma spenceri*
33. *G.* sp.
34. *Navicula* sp.

Nitzschiaceae
35. *Nitzschia seriata*
.
Phylum: <u>PYRROPHYTA (DINOFLAGELLATES)</u>
Class: Dinophyceae
Order: Dinophysales
Family: Dinophysaceae
1. *Dinophysis caudate*
2. *D. miles*
3. *D. rotundata*
4. *Ornithocercus* sp.

Order: Peridiniales
Family: Ceratiacae
5. *Ceratium breve*
6. *C. breve var. schmidtii*
7. *C. candlebrum*
8. *C. furca*
9. *C. furca var. eugrammum*)
10. *C. fusus*
11. *C. gibberum*

12. *C. horridum*
13.. *C. massiliens*
14. *C. macroceras*
15. C. trichoceras
16. *C. tripos*

Cladopyxiaceae
17. *Cladopyxis* sp

Peridiniaceae.
18. Peridinium depressum
19. P. oceanicum
20. *P*. sp. 1
21. P. sp. 2

Prorocentraceae
22. *Prorocentrum mican*

PHYLUM PRYMNESIOPHYTA
Class Prymnesiophyceae
Order Coccolithophorales
Family Coccolithophyceae
1. *Coccolithus* sp.

Phylum: CYANOBACTERIA (Blue Green Algae)
Order Nostocales
Family Oscillatoriaceae
1. *Oscillatoria thiebautii*
2. *Spirulina* sp.

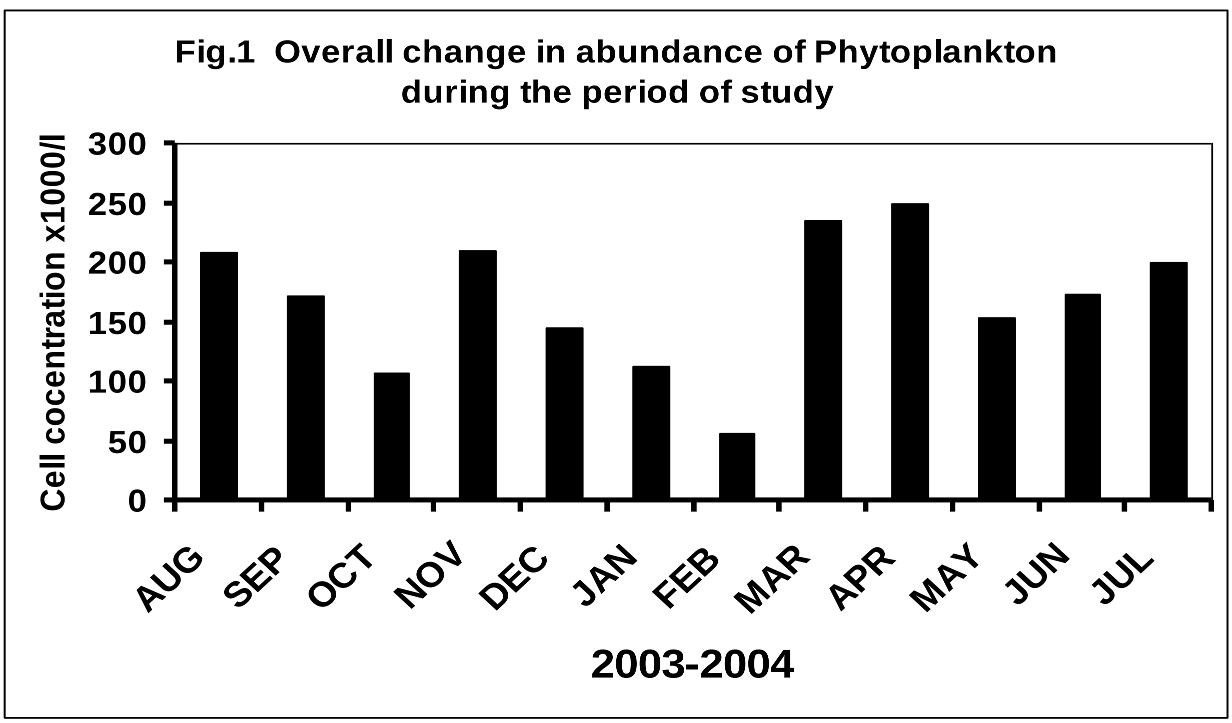

Fig. 1. Overall changes in abundance of phytoplankton during the period of study.

The diatoms were certainly the most dominant group accounting to 58% of the overall diversity of phytoplankton. Among the diatoms, centric species (23) outnumbered pennate forms (12). *Rhizosleniaceae* and *Rhizosolenia* were the most dominant family and genus among the centric diatoms respectively, whereas *Fragilariceae* among the pennate diatoms. During the period of oil spill they showed necrosis or yellowing of the colour. The chromatophores were either shrunk in size or reduced in their concentration
within the cell.

The dinoflagellates were next in dominance amounting to 37% of the total number of species. This is remarkable that only armoured (thecate) dinoflagellates were observed and not the naked forms. The armoured forms are thick walled and tolerant to different kinds of pollution including oil, whereas naked forms are delicate and more susceptible to vicissitudes of the environment. This may be the reason why the former type of dinoflagellates prevailed in the oil slick affected area. As a matter of fact, three species, i.e., *Dinophysis caudata*, *Ceratium tripos* and *Prorocentrum micans* have been reported to cause harmful algal blooms(HAB) elsewhere (Taylor and Seliger, 1979).

Another interesting feature of this study was that large size species dominated over smaller ones. Thus genera like *Coscinodiscus* and *Rhizosolenia* among diatoms and *Ceratium* and *Dinophysis* among dinoflagellates were common during the period. Large forms possess smaller surface area to volume ratio and, therefore, sink down easily to greater depths away from the euphotic zone. But, because of the presence of a thin film of oil on the surface, which is lighter than the seawater, these large forms remained at the surface.

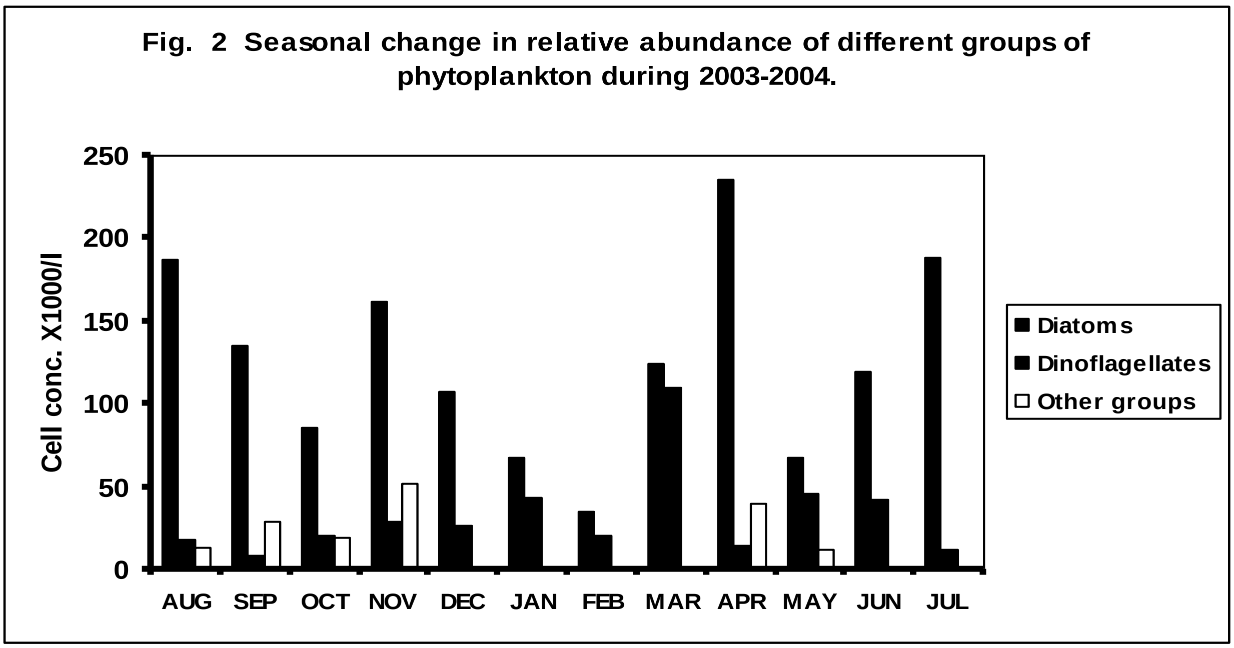

Fig. 2. Seasonal changes in relative abundance of different groups of phytoplankton during 2003-2004.

The overall change in abundance of phytoplankton during the period of study is shown in (Fig. **1,2**; Table 3, 4). It varied between 56,000 and 250,000 cells/litre; the lowest value being recorded during February and the highest in April. In general, higher values occurred in the transitional (spring) and southwest monsoon (summer) seasons. It seems the oil spill had no deleterious effect on the standing crop of phytoplankton (Clarke, 1997; Kennish, 1977). The total cell counts were as high as other natural assemblages of phytoplankton in oil free areas. Cross (1983) also did not find any deleterious effect of oil on phytoplankton abundance or chlorophyll concentrations. Oil is also known to possess growth promoting factors for phytoplankton. On the contrary other organisms in the food chain like zooplankton and benthos were mostly killed. It may be that due to the mortality of zooplankton the phytoplankton overcame the deleterious effect of oil by the reduced grazing pressure from the herbivores. Due to the mass mortality of animals the quantum of nutrients generated, also increased as a result of decomposition which in turn may have enhanced the growth of phytoplankton.

Diatoms dominated overwhelmingly other groups of phytoplankton numerically, with a range of 35,000-235,000 cells/litre. Centric diatoms were more abundant than pennate ones (Table 3). Diffferent species showed different patterns of abundance. *Coscinodiscus centralis* was the most abundant species and next were *Rhizosolenia alata* and *R. hebetat*a.

Table. 3. Abundance of Phytoplankton Species in different months (Cell No. X1000/L) of Seawater.

Name of species	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**
DIATOMS												
Biddulphiales												
Becteriastrum			3			4			12			
Biddulphia	14	5			7						7	19
Cheatoceros	24	8	6				4	8	40			
Cyclotella striata											5	6
Coscinodiscus centralis	80	65	60	9		3	17	35	89	60	40	4
Ditylum	9						4					4
Eucampia		40	5			7	4	9				
Planktoneilla sol		5								4		3
Rhizosolenia	4	7	4		60	10		18	7		9	50
Talassiothrix											7	70
Bacillariales												
Astreonella	18			40							5	
Gramatophora	4			42					50		12	
Gyrosigma	7	2						15			5	
Licmophora	9				40							
Navicula	3			7		40	4					15
Nitzschia	1						2		11		19	
Stephanopyxis turris	12	3	8			4		40		4		
Synedra	4			64					26			17
Total Diatoms	187	135	86	162	107	68	35	125	235	68	119	188

The dinoflagellates were next in abundance to diatoms but comparatively they were far less numerically and also occurred preferably in different seasons, i.e., spring and summer seasons (Fig.**2**; Table 4). Species of *Ceratium* were the most abundant among all other dinoflagellates species.

The Clifton beach is mainly sandy and, therefore, devoid of any attached seaweed growth. However, it receives seaweeds from other areas as drift forms, and these were all soiled with black oil during the period of the spill and were dead. They included mostly species of *Cystoseira, Padina, Sargassum* etc. (Shameel and Tanaka, 1992).There were, however, some very small patches of rocks scattered along the beach which allowed growth of some seaweeds like, *Ulva indica* *Entromorpha* spp. and a few others insignificant microscopic forms. All these were also smothered by oil.

The floating forms of *Enteromopha intestinalis*, however, remained floating and alive in the close vicinity of the vessel Tasman Spirit. Similar was the case with the seaweeds attached to buoys in the area. They survived the entire period of the spill. These included forms like *Ulva indica*, *Valoniopsis* sp. and *Ceramium* sp. It seems that these algae are resistant to oil pollution.

The seaweeds seemed to be the more resistant than marine animals. While most marine animals died in the affected area, the floating forms of seaweed were thrived during the period of active oil spill. As a matter of fact the attached seaweeds like *U. indica* and *Enteromorpha* sp. were the first to reappear on the rocks of Clifton beach alongwith barnacles after the oil spill was over.

Table. 4. Abundance of Dinoflagellates and other groups in different months (Cell No.X1000/L).

Name of species	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**
DINOFLAGELLATES												
Ceratium breve					4			18				
C.candelabrum					5			4				
C.furca	4			20						36		
C.fusus					4		18			7	7	
C.gibberum					5			4				
C.macrocero	1							40				
C.trichococeros					5			15				
C.tripos	1						2					
Cladopyxis Stein			2			5					8	
D.caudata			15			5					12	
D.miles			2			5		20			8	5
D.rotandata	4				3							
Omithocercus						20						
Prorocentrum micans	4	4				7		4				
Peridinium depressum	4	4	2	7		2		2	15	3	7	4
P.oceanicum				2			1	3				
Total Dinoflagellates	18	8	21	29	26	44	21	110	15	46	42	12
Names of species	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**
CYANOPHYTES												
Oscillatoria	4	12		19								
Spirulla		17			12						12	
COCCOLITHOPHORES										40		
Total other groups	4	29		19	12					40	12	
Total Phytoplankton	209	172	107	210	145	112	56	235	250	154	173	200

The mangroves grow abundantly in the backwaters of harbour and environs of Karachi. However, mangroves do not occur in the affected site of Clifton beach, mainly because of the presence of sandy substrate. Due to the prevailing wind direction, the spilled oil also did not get an access into the mangrove stands of the adjoining areas of Karachi harbour and Korangi creek, therefore, the effect of oil on the mangroves could not be observed. The abnormal symptoms like die back of trees, formation of mutant albino propagules, aberrant growth of different parts of the trees, etc. (IPIECA, 1993) as a result could not be seen. The affected beach, nevertheless, receives propagules and uprooted seedlings of these during the fruiting and germinating season and this is what happened during the oil spill. However, on this occasion they all died due to the presence of oil and one could see them scattered all over the area. This may have certainly affected seriously the coastal food chain because these are consumed by crabs and some other animals. Secondly, some of these propagules may have been transported back by tidal movements to other unaffected areas where they could have germinated into viable plants. Therefore, the oil spill has also affected the biotic potential of the mangroves.

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