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SPECIES COMPOSITION ANALYSIS OF MARINE CENTRIC DIATOMS AFTER TASMAN SPIRIT OIL SPILL

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ABSTRACT

A total of 5 phytoplankton samples from North Arabian Sea bordering Pakistan were collected just after Tasman Spirit oil spill and 16 samples after 1.5 year of spill during Bio-remedial Project. Marine centric diatoms were the targeted species in this study. Genus *Rhizosolenia* was found as the most diverse genus with 9 species which was followed by genus *Chaetoceros* with 7 species. Some genera were very rare represented by only one species. Light as well as Scanning Electron Microscopy has been used for identification of specimens. Moreover it has also been observed that species diversity was high in the samples collected after 1.5 year of the spill. Data was statistically analyzed and compared with the other reports from this area.

Key words: Phytoplankton, Northern Arabian Sea, Centric diatom, Oil Spill, Karachi Harbor, Clifton beach.

INTRODUCTION

The area of North Arabian Sea bordering Pakistan which faced largest ever recorded incidence Tasman Spirit Oil Spill (TSOS) in the history of Pakistan lies in the Sindh province at the site of Clifton, Karachi which is recognized as the largest metropolitan city of Pakistan (Siddique *et al.*, 2009). Karachi coastline comprises of rocky ledges as well as sandy beaches which receives water from Baluchistan and Indus delta shelf. The Clifton beach Karachi is a sandy area with smooth and distinct appearance of mica content (UN-CEMP, 1996). The two small rivers namely Malir and Lyari open in the coastal area and bring industrial, agricultural and domestic wastes into the beach area.

This area also acquires disparity in physical parameters like surface water temperature and salinity due to seasonal variation of northeast monsoon and southwest monsoon seasons which is a unique feature (Latif *et al*., 2013) among which later one is known for high production of phytoplankton in the specific area (Anand *et al*., 2008).

Phytoplankton which contribute nearly half of the global annual primary productivity and show decline in their availability due to anthropogenic activities as well as climatic instability all over the world (Boyce *et al*., 2010). Diatoms, a dominant fraction of phytoplankton community, play a significant role in environmental remediation by absorbing pollutants from contaminated water (Anantharaj *et al.*, 2011) and are considered as the biological indicator of water quality (Noga *et al*., 2013). On the other hand polluted environment specifically as a result of an oil spill inhibits the growth of diatoms (Parab, *et al.*, 2008) by decreasing metabolic activities, (Lewis and Pryor, 2013), chl. ‘a’ concentration (Lee *et al*., 2009) and photosynthetic capabilities (Singh and Gaur, 1988). Although in some cases no noteworthy effect was recorded on planktonic community structure of southern Irish Sea and Hong Kong Island south (Batten *et al.*, 1998; Shin, 1988). This may be due to the fact that oil pollution depends greatly on its concentration at the time of spill and its effects varies with the tolerance of species present (Sheekh *et al*., 2000). Moreover it is also observed that high concentration of crude oil significantly reduces the growth of phytoplankton whereas its low concentration increased their growth rate (Huang *et al.*, 2011).

Though studies were conducted on some flora and fauna of the affected area and its vicinage but seem to be incomplete without detailed assessment of diatom assemblages during the largest event of this kind in North Arabian Sea bordering Pakistan (Baig *et al.*, 2004; Baig *et al*., 2007; Saifullah and Chaghtai, 2005). The key purpose to conduct this study was to investigate the effects of oil spill on centric diatoms of the affected area. A comparison was also made with the historical record available to observe the change in centric diatom community structure before and after spill.

MATERIALS AND METHODS

The study area affected by Tasman Spirit Oil Spill (TSOS) stretches from harbor to sea view Clifton whereas post spill studies after 1.5 year of spill during Bioremedial Project (BP) cover the area from Khuddi creek to Manora channel. Phytoplankton samples were collected by net hauls of mesh size 50 µm at a speed of 2 knot during both the study periods i.e. 5 stations after TSOS in 2003 and 16 stations during BP in 2005 (Fig. 1 and Table 1). Samples were immediately fixed with 10 % buffered formalin. Simultaneously physical parameters including water temperature, salinity and pH were also recorded during TSOS (Table 2) and BP (Tables 3) studies. Washed and treated samples were then examined under light and Scanning Electron Microscope for identification of centric diatom species.

Measurement of Diversity:

After identification of species analyses were performed using statistical program 'Diver' that was developed in GWBASIC for the IBM compatible personal computer. Site preference was determined by the Shannon-Weiner information theory function Shannon & Weiner index (Shannon and Weaver, 1949):

$$H = - \sum_{i=1}^{s} \text{pi} \ln \text{pi}$$

'H' denotes diversity index, 'i' denotes counts of ith species
'pi' denote proportion of the total number N belonging to the ith species (Margalef, 1957).

The components of general diversity developed by Margalef (1957) including species richness and equitability (Pielou, 1969) were also calculated in this study. The former one was expressed as:

$$d' = (S-1)/lnN$$

'd' denotes species richness
'*s*' denote number of species
'N' denotes total number of individuals of '*s*' species
Whereas, the later one was calculated by:

$$J = H/H_{max} = H/S$$

'J' denotes equitability index
H_{max} = log S' (Pielou, 1969)
'S' denotes number of species in a population

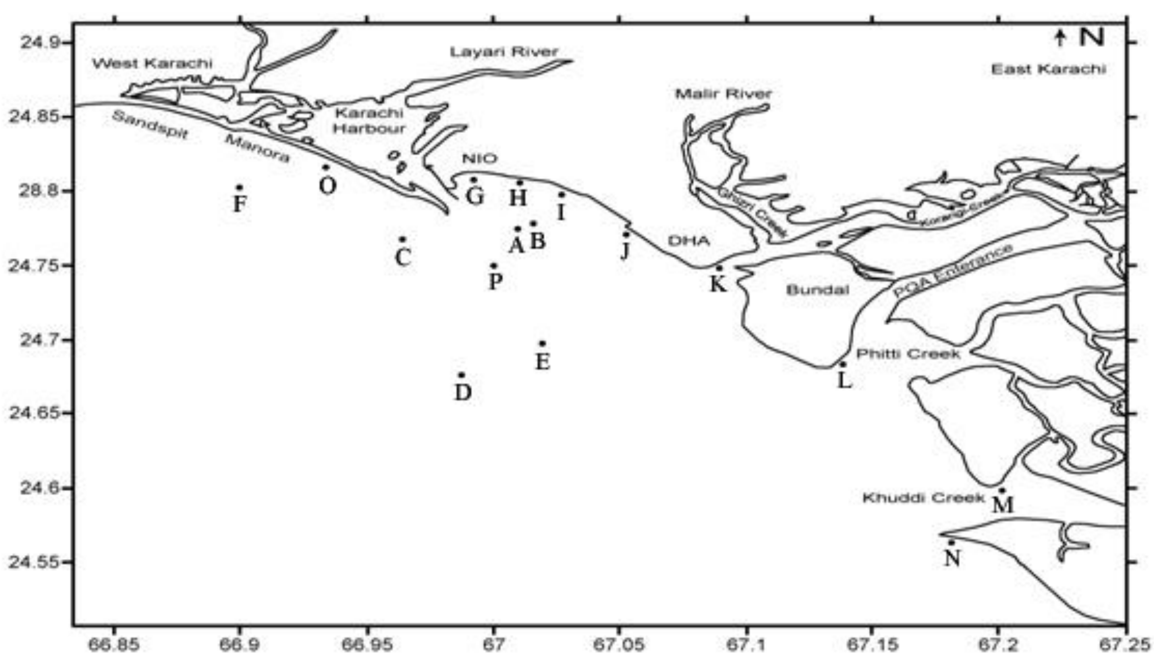

Fig. 1. Sampling sites covered during 2 study periods TSOS & BP. The alphabets indicate the number of stations.

Table 1. Details of number of stations covered during the two study periods.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Study Periods	Sampling stations occupied															
TSOS	1	2	3	4	5	-	-	-	-	-	-	-	-	-	-	-
BP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Table 2. Details of samples collected from sampling sites after TSOS.

Station	**Date**	**Latitude N**	**Longitude E**	**Salinity**	**pH**	**Water Temperature**
1	19/11/2003	24°80’248N	66°89’938E	36	8.3	22.1
2	19/11/2003	24°80’816N	66°99’215E	36	8.3	22.1
3	19/11/2003	24°80’771N	67°01’087E	36	8.3	22.1
4	19/11/2003	24°79’753N	67°02’718E	36	8.3	22.1
5	20/11/2003	24°77’204N	67°05’435E	36	8.3	22.1

Table 3. Details of samples collected from sampling sites during BP.

Station	**Date**	**Latitude N**	**Longitude E**	**Salinity**	**pH**	**Water Temperature**
1	22/02/2006	24.7747	67.0097	36	8.37	26
2	22/02/2006	24.7783	67.0158	36	8.36	26
3	24/02/2006	24.768	66.9641	36	8.2	25.8
4	24/02/2006	24.6758	66.9872	36	8.41	25.7
5	24/02/2006	24.6966	67.0188	36	8.52	25.6
6	22/02/2006	24.8025	66.8994	36	8.45	25
7	22/02/2006	24.808	66.9922	36	8.45	25
8	22/02/2006	24.8077	67.0108	36	8.45	26.7
9	22/02/2006	24.7975	67.0272	36	8.39	26.5
10	22/02/2006	24.7719	67.0544	37	8.42	27
11	23/02/2006	24.7506	67.0886	35	8.56	27
12	23/02/2006	24.5992	67.2009	36	8.29	27
13	23/02/2006	24.685	67.1378	37	8.34	27
14	23/02/2006	24.5665	67.1814	37	8.28	26
15	24/02/2006	24.8154	66.9334	37	8.51	25.3
16	24/02/2006	24.7498	67.0006	36	8.51	25.6

RESULTS AND DISCUSSION

In this study a total of 40 species of centric diatoms belonging to 15 genera were recorded. Among which 17 species belonging to 4 genera isolated from samples collected from TSOS. Whereas 31 species from 15 genera were recorded from samples collected after 1.5 year of spill in BP. *Rhizosolenia* and *Chaetoceros* were the most diverse of all genera represented by 10 & 8 species respectively. There were 10 genera observed with very poor species diversity and reported by only one species including *Planktoniella, Stephanopyxis, Hemidiscus, Asteromphalus,* *Eucampia*, *Proboscia*, *Pseudosolenia*, *Dactyliosolen*, *Bellarochea* and *Bacteriastrum*. Moreover genera *Ch. pseudocurvisetus*, *Chaetoceros pseudosymmetricus* and *Bellarochea malleus* were first time isolated from the study area of North Arabian Sea bordering Pakistan.

In this study cells with unusual structure were also observed in the samples of both the study periods. Such deformity in the cell structures were also previously reported after an oil spill in another area (Jaiswar *et al*., 2013). Comparison of 5 common stations of both the study periods showed that some species were common whereas most of the species occurred distinctively either in TSOS or in BP.

Comparison of present investigation with the studies previously conducted (before oil spill) in the same area (Baig and Rabbani, 1995) showed variation in phytoplankton assemblage specially centric diatom species. Conversely after 1.5 year of spill in BP an elevated number of species were recorded closed to the records of this area which indicated decline in assemblages of centric diatom species due to hazards of crude oil and its reoccurrence in the later period.

Our findings in present investigation are in complete agreement with the studies conducted by the other investigators after an oil spill in different regions showing low species diversity and dominance of fast growing centric diatoms (Dahl, 1983; -Carrera-Martinez *et al*., 2010; Hallare *et al*., 2011; Jaiswar *et al*., 2013). Hydrographic parameters observed in this study appeared to be similar in ranges recorded earlier in the same area (Baig and Rabbani, 1995) which showed spill has more pronounced effect on the assemblages of centric diatoms than any other physical or environmental factors.

There were five sampling stations commonly studied during TSOS and BP which showed that very few common genera of centric diatoms isolated in both the study sites. The common species were *Coscinodiscus asteromphalus*, *C. wailesii*, *Odontella mobiliensis*, *Rhizosolenia imbricata* and *Chaetoceros eibenii*. Studies on *Coscinodiscus wailesii* showed that during its bloom condition this specie is capable of producing large amount of mucilage (Edwards *et al*., 2001) which might be the reason of its tolerance and its continuous appearance in TSOS and BP samples. Similarly presence of *Chaetoceros* in both TSOS and BP might be due to the reason that some species of *Chaetoceros* also showed tolerant response against specific concentration of pollution caused by petroleum hydrocarbons (Desai *et al*., 2010). Similarly, presence of *Rhizosolenia* being fast growing diatom is also reported by other worker in other area after an oil spill showing its tolerance to petroleum hydrocarbons (Hallare *et al*., 2011).

Statistical analysis showed notable difference in centric diatom species diversity (Fig. 2), equitability (Fig. 3) and richness (Fig. 4) between TSOS (October) and BP (April) in pooled data of both the study periods indicating high species diversity of centric diatoms in the samples of BP. The results of present study were significantly different from previous studies conducted in same area showing clear decline in diatom assemblages (Baig and Rabbani, 1995) indicating negative effects of crude oil on centric diatoms after Tasman Spirit Oil Spill. Conclusively a long term study is needed to monitor the health of the coastal area with reference to reoccurrence of centric diatoms.

Table 4. Local Distribution of species in stations of TSOS.

S. No.	Species	Stations				
		1	2	3	4	5
1	*Planktoniella sol*	-	-	-	-	-
2	*Stephanopyxis turris*	-	-	-	-	-
3	*Coscinodiscus asteromphalus*	-	+	-	-	-
4	*C. excentricus*	-	-	-	-	-
5	*C. jonesianus*	-	+	-	-	+
6	*C. radiatus*	-	+	-	-	-
7	*C. wailesii*	-	+	-	-	-
8	*Hemidiscus kanayanus*	-	-	-	-	-
9	*Asteromphalus elegans*	-	-	-	-	-
10	*Odontella aurita*	-	+	-	-	-
11	*O. mobiliensis*	+	-	+	+	-
12	*O. regia*	+	+	-	-	-
13	*O. sinensis*	-	+	-	-	-
14	*Eucampia zodiacus* f. *zodiacus*	-	-	-	-	-
15	*Rhizosolenia crassa*	-	-	-	-	-

16	*R. fallax*	-	-	-	-	-
17	*R. formosa*	-	-	-	-	-
18	*R. hebetata* f. *hebetata*	-	-	-	-	-
19	*R. hyalina*	-	-	-	-	-
20	*R. imbricata*	-	+	-	-	-
21	*R. setigera*	-	-	-	-	-
22	*R. simplex*	-	-	-	-	-
23	*R. striata*	-	-	-	-	-
24	*R. styliformis*	-	+	-	+	-
25	*Proboscia indica*	-	-	-	-	-
26	*Pseudosolenia calcar-avis*	-	-	-	-	-
27	*Guinardia delicatula*	-	-	-	-	-
28	*G. flaccida*	-	-	-	-	-
29	*G. striata*	-	-	-	-	-
30	*Dactyliosolen phuketensis*	-	-	-	-	-
31	*Chaetoceros compressus*	-	-	-	-	-
32	*Ch. eibenii*	-	+	-	-	-
33	*Ch. Lorenzianus*	-	+	-	-	-
34	*Ch. pseudocurvisetus*	-	+	-	-	-
35	*Ch. pseudosymmetricus*	-	+	-	-	-
36	*Ch. socialis*	-	+	-	-	-
37	*Ch. subsecundus*	-	+	-	-	-
38	*Ch. teres*	-	-	-	+	-
39	*Bellarochea malleus*	-	-	-	-	-
40	*Bacteriastrum delicatulum*	-	-	-	-	-

+ = Present; - = Absent; TSOS = Tasman Spirit Oil Spill

Table 5. Local distribution of species in stations of BP

S. No.	Species	Stations															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	*Planktoniella sol*	-	-	-	+	-	-	-	-	-	-	-	+	+	-	-	-
2	*Stephanopyxis turris*	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+
3	*Coscinodiscus asteromphalus*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
4	*C. excentricus*	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-
5	*C. jonesianus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	*C. radiatus*	-	-	+	-	-	-	-	-	-	-	+	+	-	+	-	+
7	*C. wailesii*	-	-	-	+	-	-	-	+	-	+	-	+	-	+	-	-
8	*Hemidiscus kanayanus*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
9	*Asteromphalus elegans*	-	-	-	+	-	-	-	-	-	-	-	+	+	+	-	-
10	*Odontella aurita*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	*O. mobiliensis*	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
12	*O. regia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	*O. sinensis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	*Eucampia zodiacus* f. *zodiacus*	+	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-
15	*Rhizosolenia crassa*	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-
16	*R. fallax*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
17	*R. formosa*	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	+
18	*R. hebetata f. hebetata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
19	*R. hyalina*	+	-	-	-	-	-	+	-	+	+	-	-	-	-	-	-
20	*R. imbricata*	+	+	-	+	-	+	+	-	+	+	-	+	-	-	-	+

+ = Present; - = Absent; BP = (Bioremedial Project)

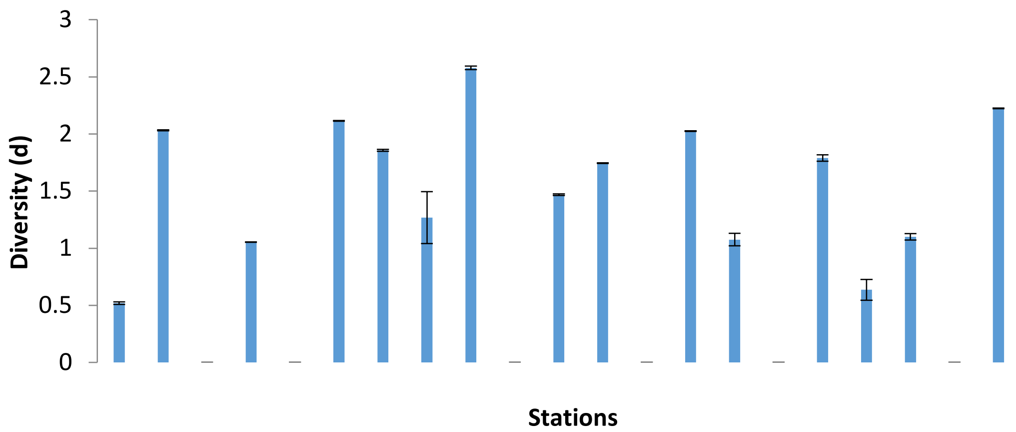

Fig. 2. Graphical representation of Shannon-Wiener's diversity index in pooled samples

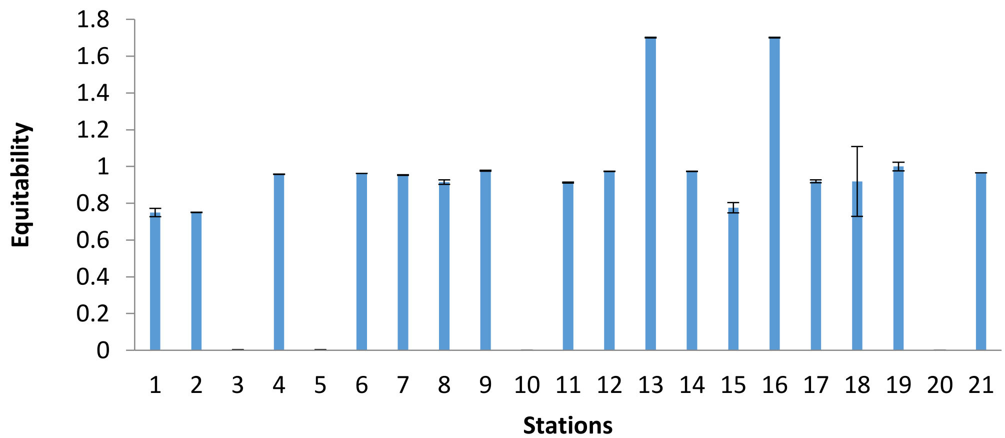

Fig. 3. Graphical representation of Pielou's species equitability of pooled samples

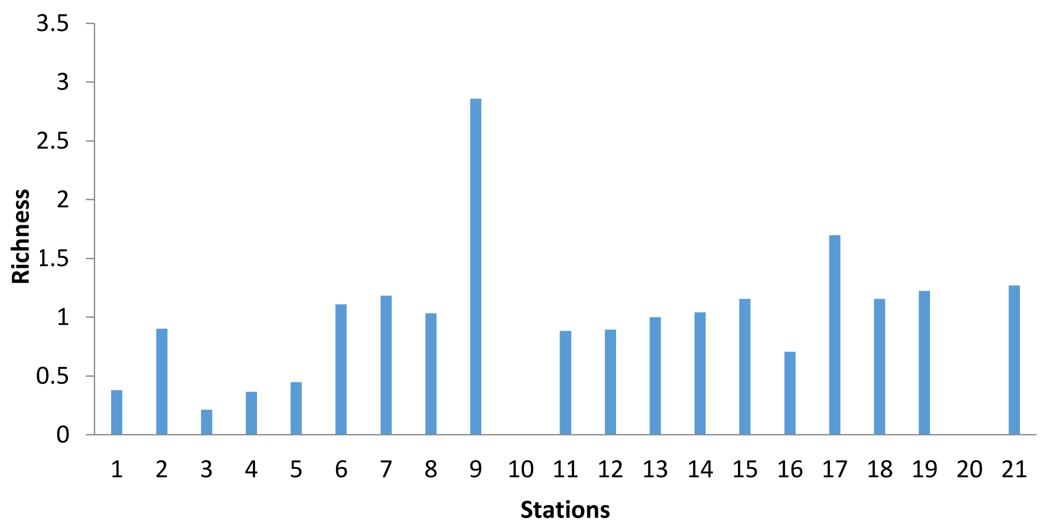

Fig. 4. Graphical representation of Margalef's species richness index in pooled samples

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