Petroleum pollution by Volgoneft-248 tanker accident occured on 29.12.1999 in İstanbul, Florya-Küçükçekmece area (1)

Volgoneft-248 tanker kazası sonrası İstanbul, Florya-Küçükçekmece bölgesinde 29.12.1999' da meydana gelen petrol kirliliği ⁽¹⁾

Erdoğan Okuş, Kasım C. Güven*, Ayhan Uysal, Selma Ünlü, Tuncay Gezgin, Filiz Nesimigil, Selin Cumalı and Ahmet Yalçın

İstanbul University, Institute of Marine Sciences and Management, Müşküle sokak 3, 34116 Vefa, İstanbul, Turkey.

Abstract

In this work petroleum pollution of Volganeft-248 tanker accident was investigated in Florya and Küçükçekmece area in Sea of Marmara. After the accident 4365 tones oil spill in this area. The analysis was made by UVF and GC/MS during the 40 months survey. After the accident the oil pollution was 14.05 g/L at S_3 seawater and 441 $\mu g/g$ at A_4 sediment. The oil pollution has decreased to 0.94 $\mu g/L$ in seawater and to 9.6 $\mu g/g$ in sediment in April 2003.

Keywords: Volgoneft-248, accident, Florya, Küçükçekmece

Introduction

Russian flagged tanker VOLGONEFT-248 (4,039 DWT) loaded 4365 tons of fuel from Bourgas/Bulgaria and anchored off Ambarlı fuel oil terminal by passing through the Istanbul Strait in order to discharge his cargo. On the 29.12.1999 around the morning hours, firstly chain cable of the vessel came

^{*}Corresponding author: kcguven@istanbul.edu.tr

⁽¹⁾ This is a part of the report of "Petroleum Pollution of Volgoneft 248 Tanker Accident in the Florya-Küçükçekmece Area" prepared by İstanbul University, Institute of Marine Sciences and Management. All rights are reserved. No part of this article may be reproduced in any form or utilized in a paper without permission from the director of Institute of Marine Science and Management.

of due to the heavy South Wind storm and the vessel split into two about 1km away from shore. Bow part sank at once and aft side of vessel drifted and grounded at shore of Küçükçekmece, Menekşe District. As a result 1279 tons of fuel oil existing in fore tanks No: 5 and 6 spilled into the sea. Due to the 2073 tones existing in four tanks at fore side and 1013 tones of fuel oil existing in tanks No: 7 and 8 at aft side spilling into sea until the divers closing the holes at fore side, thus totally 4365 tones of fuel oil spread to the accident area.

The fuel oil spilled into the sea spread to around 7 km area of Florya Shore rapidly in a few hours due to heavy wind blowing storm and relevant waves. Wideness of fuel oil at shore is between 2 to 10 meters in some areas, thickness of fuel oil on sea surface reached 5 cm. Barriers were laid around the vessel in order to avoid leakage of remaining fuel oil.

There is sandy rock, concrete platform at shore close to the accident area and there are a lot of restaurants, sea side cafes, summer houses in that area. The fuel oil, which is thick and adhesive in low temperatures during winter months, filled in the spaces between sand grains at sea bottom and as a result, sand sheets saturated with fuel occurred at the sea bottom. Thus, great part of the fuel oil floating at shore was covered up with sand and spread in sheets over the sea bottom along the shore. It was observed that fuel oil accumulation was high in the area between Engelliler Kampı and Marmara Motelleri. The mussel shell smeared to the fuel oil came to shore. Thus, a great many districts in vicinity were affected by fuel oil pollution. The sea birds were affected badly by the pollution and died.

Operations were carried out in order to remove the pollution by the relevant commission and Crisis Committee constituted by Istanbul Governorship. Thus, the whole shore affected by pollution and smeared with petroleum was cleaned many times and after discharging remaining bunker in the sunken part of VOLGONEFT-248, the wreck was removed.

In this paper the petroleum pollution of seawater and sediments were reported after tanker VOLGONEFT-248 accident on the 29/09/1999 in Florya- Küçükçekmece area, Sea of Marmara.

Material and Methods

The sampling was made by R/V ARAR on the date of; 30 December 1999, 3 January 2000, 23 February 2000, 23 May 2000, 15 August 2000, 26 January 2001, 10 August 2001, 25 January 2002, 10 April 2003 and continued yearly until 2006.

The sampling stations in the accident area are shown in Figures 1 and 2.

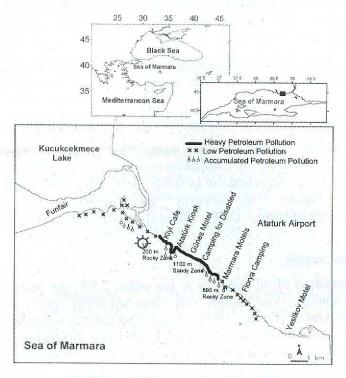
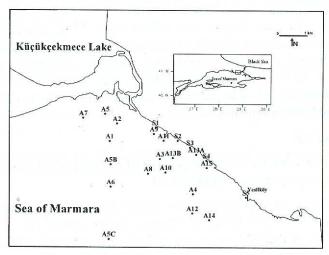


Figure 1. The map of accident area



Sampling stations in the accident area

Figure 2.

Sea water sample was taken from surface by special apparatus, at 10 m and depth water by Niskin apparatus. The sample was transferred to 3 L cleaned brown flacon and 15 ml dichloromethane (DCM) was added for preservation.

The sediment sample was taken with Van Veen grap apparatus. The sample was placed in aluminium foil with a spatula and kept in deep freeze until analysis.

The Standard curve and equation of VOLGONEFT-248 fuel oil

Oil pollution was determined using a standard curve equation drown with the VOLGONEFT-248 fuel oil. Calibration curve of VOLGONEFT-248 fuel oil was plotted in a concentrations of 0.005, 0.01, 0.02, 0.03, 0.04 and 0.05 μ g/ml in hexane. Its intensity was measured by Ultraviolet fluorospectrophotometer, UVF, (Shimadzu, RF-1501) at 310/360 nm (ex/em).

1. Sea water sample

For determination of oil pollution in sea water, 2.8 L sea water was taken from the stations. The sample was extracted three times with 50 ml dichloromethane (Lab Scan, HPLC grade). The extracts were combined and dried over sodium sulphate anhydrous, filtered and distilled at 36 °C. The intensity was measured at 310/360 nm (ex/em) by UVF and the amount of oil level was calculated by using standard curve equation.

2. Sediment sample

20 g of wet sediment sample was mixed with 25 g sodium sulphate anhydrous and extracted with DCM in Soxhlet apparatus for 8h. The DCM extract was filtered and dried over sodium sulphate anhydrous, re-filtered and distilled at 36 °C. The residue was taken with hexane and the volume was adjusted to 10 ml with the same solvent and the oil amount was determined by UVF as indicated above.

3. GC/MS analysis

This method was used for the determination of oil components subsequently and also to prove the origin of pollutant oil.

After determination of oil amount in the sample by UVF, the remaining part was hydrolyzed with 5% KOH in ethanol, under reflux for 2 h. After hydrolysis 50 ml of distilled water was added, then extracted with 25 ml of pentane. The pentane phase was separated and distilled. The residue was taken with hexane and analyzed by GC/MS.

GC (HP 6890) coupled to mass spectrophotometer HP 5972 A. A split/splitless injector was used, injection; 2 μ l split time: 1 min, flow 60 ml min⁻¹. Column; HP-5MS: 30 m x 0.25 mm x 0.25 μ m, The injector temperature was maintained at 280°C. The GC temperature programme was: from 50°C (1 min) to 320°C at 5°C min⁻¹. The carrier gas was helium, flow rate 1 ml min⁻¹. Mass spectral data: SIM (Selective Ion Monitoring Mode).

The petroleum components on chromatogram were identified by using HP memory and the results were compared with the petroleum components of VOLGONEFT 248 fuel oil.

4. Fingerprinting method (Boehm et al., 1983)

The fingerprinting chromatogram of VOLGONEFT 248 fuel oil was compared with fingerprinting chromatogram of the samples. The markers used were dibenzothiophene (DBT) (m/z 184.03) and its alkylated derivates C1-DBT (m/z 198.05) and C2-DBT (m/z 212.06).

Results

The GC/MS chromatogram of Volganeft-248 and after the accident the oil extracted in seawater are shown in Figures 3 and 4. The petroleum component detected by GC/MS in Volganeft-248 fuel and seawater sample are shown in Table 1.

1. UVF analysis

The standard curve equation of VOLGONEFT 248 fuel oil is:

 $F_1 = 1304.7xC + 79.149$

 r^2 : 0.99

F_{1:} Fluorescence intensity, C: Concentration

2. Oil pollution of seawater

Oil pollution levels in sea water samples and on coast-line of examined stations are shown in Table 2 and 3 and their graphical representation in Figures 5-7.

After the accident on 29.12.1999, the surface of sea water was completely covered by oil at the stations S_1 , S_2 and S_3 .

As seen in the Table 2 the highest oil pollution was found on the 29.12.1999 at station S_3 as 14.05 g/L and 2 month later (03/01/2000) at station S_2 as 450 μ g/L and 10 months after the accident the concentration of oil at station S_1 was 567.60 μ g/L. International limit value of oil pollution for sea water given by WHO (1982) is 2.5 μ g/L and for coastal area 5 μ g/L by Law (1981). The oil value was found at station S_3 in 19.12.1999 is 2.8 million times higher than international limit value.

The results out of barrier are shown in Table 4. The highest pollution was found at station A_5 as 2.17 mg/L (2178 μ g/L) in 30.12.1999. This value was 435 times higher than limit value.

As seen in this Table the oil pollution was high on 10/08/2001 at the following stations; at A_4 50.63 $\mu g/L$ at 34 m, at A_{5b} 125.50 $\mu g/L$ at 51 m, at A_{5c} in surface water 121.50 $\mu g/L$ and 146.70 $\mu g/L$ at 75 m.

These findings showed that the oil pollution value was changed depending on the wave by heavy wind. The different findings on the pollution values among the stations during the time are depended on the dispersion of the oil which sticked on sand of depth.

The highest pollution levels were found in the following stations;

Over 100 μ g/L: at A_{51} at 51 m on the 10/08/2001, at A_{5c} surface and 75 m depth in 10/08/2001.

Over 50 µg/L; at A₄ station at 34 m depth.

The stations showing oil pollution over the international limit value were:

A₄ at surface; 12/1999, 01/2000, 2/2000, 8/2000, 8/2001, at 10 m; 2/2000, at 34 m; 12/1999, 1/2000, 2/2000, 8/2001.

A₅ at surface; 12/1999, 2/2000, 5/2000, 8/2000, 8/2001: at 6 m; 12/1999, 1/2000, 5/2000, 8/2001.

 A_{5b} at surface; 12/1999, 1/2000, 2/2000, at 10 m; 1/2000, 2/2000, 8/2001, at 51 m; 2/2000, 8/2001, A_{5c} at surface water; 2/2000, 8/2000, 8/2001, at 10 m; 1/2000, 8/2000, 8/2001, at 75 m; 12/1999, 1/2000, 2/2000, 8/2001.

The pollution was decreased to under international limit value in sea water after the 25/02/2002 and 10/04/2003.

3. Sediment

The GC/MS chromatogram of sediments taken in station A_6 at 54 m after the accident is shown in Figure 8.

The oil pollution levels in sediment found are shown in Table 4 and its graphical representation in Figure 9.

The findings were compared with international limit value 10 $\mu g/g$ in sediment given by National Academy of Science (NAS, 1975).

The oil concentrations of sediments found in the stations were:

Over the 100 μ g/g: A₄; 441.0 μ g/g (23/05/2000), A₁₄; 229.0 μ g/g (26/01/2001), A₁; 189.0 μ g/g (03/01/2000), A₅; 185.0 μ g/g (23/02/2000).

Between 75 and 100 μ g/g: at A₃; 03/01/2000, 23/02/2000, 23/05/2000, at A₉; 26/01/2001.

Between 50 and 75 μ g/g: at A₁; 30/12/1999, 03/01/2000, 23/02/2000, 15/08/2000, 25/01/2002, at A_{5b}; 23/05/2000, at A₆ 25/01/2002.

Between 25 and 50 μ g/g: at A₈, A_{5b}, A₁₀, A₁₂, A₁₄, A₁₆; 15/08/2000.

Between 10 and 25 μ g/g: at A₃, A_{5b}; 30/12/1999, 15/08/2000, at A₅; 30/12/1999, at A_{5c}; 23/02/2000, 26/01/2001, at A₈, A₁₃, A_{13b}; 23/05/2000, at A₁₂; 15/08/2000, at A₂ 26/01/2001, at A₆, A₈, A₉, A₁₀, A_{13b}, A₁₅; 10/08/2001, at A₄, A₁₃; 25/01/2002.

The oil pollution level at A_4 sediment is 44.1 times higher than international limit value.

4. Fingerprinting results

The peaks of dibenzthiophene (DBT) and its alkyled derivatives were compared on the chromatogram of VOLGONEFT-248 with the samples.

It was found that the fingerprinting chromatograms of surface sea water sample at station A_3 taken after the accident on the 30.12.1999 and at Kıyı Kafe on the 25.01.2002 and the sediment sample taken on the 30.12.1999 at station A_3 , A_5 , A_6 , on 03.01.2000 at A_1 , at A_3 , on 23.05.2000 at A_9 , A_4 , on 10.08.2000 at A_3 , A_{13} , A_1 , A_5 , on 26.01.2001 at A_2 , A_9 , A_{10} , A_{11} , on 25.01.2002 at A_{11} , A_{13} are similar with VOLGONEFT–248 results (with some minor exception due to the time).

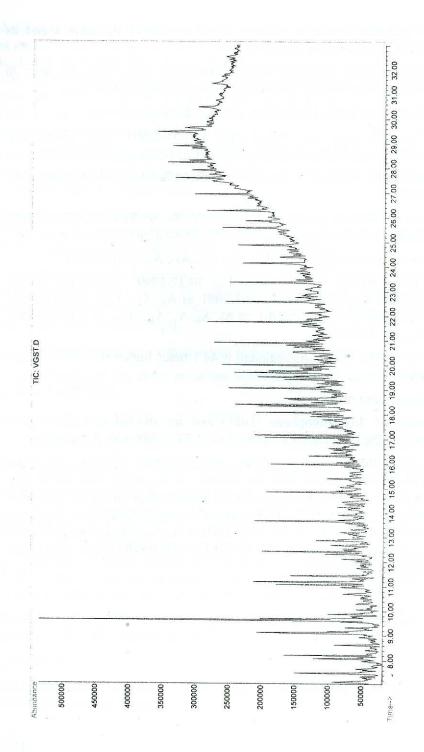


Figure 3. GC/MS chromatogram of Volgoneft-248 oil.

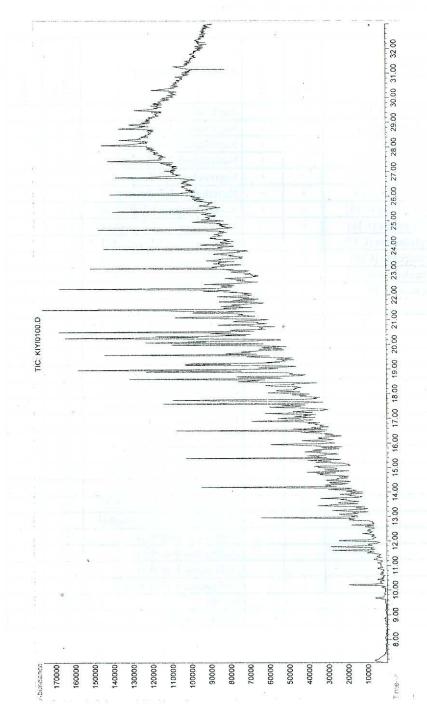


Figure 4. GC/MS chromatogram of seawater taken from off shore after the accident area.

Table 1. Petroleum components of VOLGONEFT-248 fuel oil and in sea water taken after accident at the right side of Florya

Aliphatic components	Volgoneft- 248	Florya	Aromatic components	Volgoneft- 248	Florya
Undecane (C11)	+	+	Naphthalene	+	+
Dodecane (C12)	+	+	Naphthalene,1-methyl	+	+
Undecane, 2,6-	+	+	Naphthalene,2-ethyl	+	+
Tridecane (C13)	+	+	Naphthalene,2,6-dimethyl	+	+
Tetradecane (C14)	+	+	Naphthalene,2,7-dimethyl	+	+
Dodecane, 2, 6, 10-	+	+	Naphthalene,1,5-dimethyl	+	+
Pentadecane (C15)	+	+	Acenaphthalene, 1,2, dihydro	+	+
Hexadecane (C16)	+	+	Naphthalene,2,3,5-trimethyl	+	+
Heptadecane (C17)	+	+	Naphthalene, 1, 4, 6-trimethyl	+	+
Octadecane (C18)	+	+	Naphthalene, 1,6,7-trimethyl	+	+
Nonadecane (C19)	+	+	Naphthalene,2,3,6-trimethyl	+	+
Phytane (C20)	+	+	9H-Fluorene	+	+
Eicosane (C20)	+	+	9H-Fluorene,1-methyl	+	+
			9H-Fluorene,2,3-dimethyl	+	+
			Dibenzothiophene	+	+
			Methyldibenztiofene	+	+
			2,6-dimethylbenzthiophene	+	+
			2,8-dimethylbenzthiophene	+	+
			3,4-dimethylbenzthiophene	+	+
	115		Phenanthrene	+	+
			Phenanthrene,9-methyl	+	+
			Phenanthrene, 1-methyl	+	+
			Phenanthrene ,3,6-dimethyl	+	+
			Phenanthrene ,2,7-dimethyl	+	+
			Phenanthrene ,2,5-dimethyl	+	+
			Phenanthrene,2,3,5-trimethyl	+	+
			Anthracene,2-methyl	+	+
			Anthracene,9-methyl	+	+
			Anthracene,1-methyl	+	+
			Anthracene,9,10-dimethyl	+	+
	9		Pyrene	+	+
			Pyrene,1-methyl	id.	+

|--|

Same Substitution 29/12/1999 30/12/1999 33/01/2000 23/05/2000 23/05/2000 15/08/2000 26/01/2001 10/08/2001 25/01/2002 10/04/2003 S ₂ +(*).(**) 94.00 22.50 13.90 51.42 83.20 1.25 567.60 62.10 0.94 S ₂ + + 450.0 7.21 52.50 247.80 314.20 94.80 - - S ₃ 14050000 55.00 20.10 16.60 20.20 - - - - - S ₄ 47.00 79.30 10.40 13.90 - 1,15 - - - - S ₅ - - 0.75 0.12 - - - - - -	Chotions	Sampling ti	time .		-						
+(*),(**) + 14050000 (***) 47.00	Stations	29/12/1999	30/12/1999	03/01/2000	23/02/2000	23/05/2000	15/08/2000	26/01/2001	10/08/2001	25/01/2002	10/04/2003
+ + + 450.0 7.21 52.50 247.80 314.20 94.80 - 14050000 55.00 20.10 16.60 20.20 - - - - 47.00 79.30 10.40 13.90 - 1,15 - - - - 0.75 0.12 - - - - - -	S_1	+(*),(**)	94.00	22.50	13.90	51.42	83.20	1.25	567.60	62.10	0.94
14050000 55.00 20.10 16.60 20.20 - - 47.00 79.30 10.40 13.90 - 1,15 - - 0.75 0.12 - - -	S_2	+	+	450.0		52.50					
47.00 79.30 10.40 13.90 - 1,15 - - - 0.75 0.12 - - -		14050000	965			20.20					
0.75 0.12	S_4				13.90		1.15				
	S _s				0.12						

(S₁) Kıyı Café space 50 m right* and left side (**), (S₂) Uludağ Restaurant behind, (S₃) Engelliler Camp behind, (S₄) Belediye Dinlenme Tesisleri önü,

(S₅) Çiroz Plajı, +: Surface layer was covered by oil, -: No sampling

(***):14.05 g/L

81	Sampling	Sampling			S	Sampling time	40			
Stations	depth(m)	30.12.1999	03.01.2000	23.02.2000	23.05.2000 15.08.2000	15.08.2000	26.01.2001	10.08.2001	25.01.2002	10.04.2003
B	Surface	3.75	88.5	48.5	24.2	4.46	2.05	9.18	0.43	0.13
A,	10 4	68.5	0.4	0.62	28	18.6	0.38	9.13	0.13	0.05
	27	3.28	58.5	37.1	18.6	2.39	0.46	6.64	80.0	0.03
	Surface	5.67	45.3	0.45	17.9	0.27	5.0	7.17	0.15	0.1
A_2	10	61.4	73.9	54.2	43.2	12.8	0.31	20.9		0.01
	Surface	3.58	68.5	0.45	58.9	1.3	0.55	17.5	1.34	90.0
A3	10	6.9	0.3	16.9	20.7	15.5		8.65	0.11	0.1
	15	9.0	1.47	39.2	67.1	1.17	0.35	4.64		,
	Surface	28.28	51.7	39.2	2.42	28.5	0.17	17.4	0.71	80.0
Λ_4	10	2.47	8.07	48.2	0.57	1	0.25	4.78	0.57	90.0
	34	19.2	29.4	17.7	1.18	66.0	0.44	50.63	0.1	0.02
	Surface	2178.5*	1.51	44.6	23.9	24.6	0.65	25.26	0.16	90.0
As	9	13.3	88.5	0.37	17	13	0.82	26.98	0.1	0.02
- 2	Surface	37	80.7	62.1	0.26	19.0	6.35	3.71	0.16	0.08
Ash	10		92	17.2	1.24	0.11	4.32	21.4	0.18	60.0
	51	4.85	1.19	60.3	0.17	1.6	0.37	125.5	0.11	
	Surface	12.2	-	36.4	7.97	46.4	0.62	121.5	0.11	
Asc	10	9.64	43.2	11.8	0.1	14.3	0.25	29.9	0.12	0.2
	75	14.1	585	177	0.87	0.15	0.21	146.79	a	0

* 2 17 mo/I

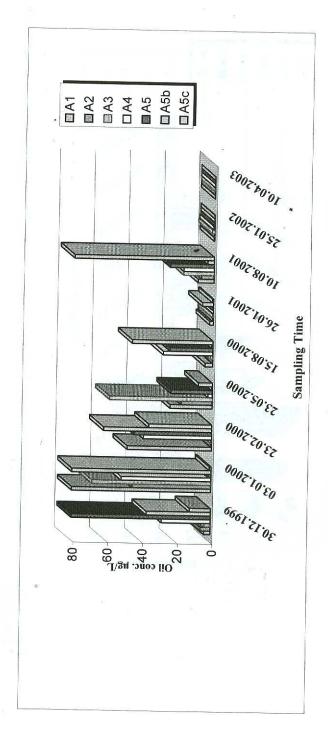


Figure 5. Graphical representation of oil pollution in surface water samples during the monitoring of 30.12.1999 – 10.04.2003.

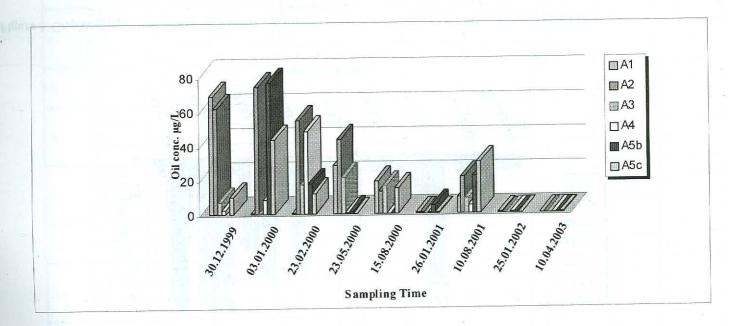


Figure 6. Graphical representation of oil pollution in 10 m depth sea water samples during the monitoring of 30.12.1999 – 10.04.2003.

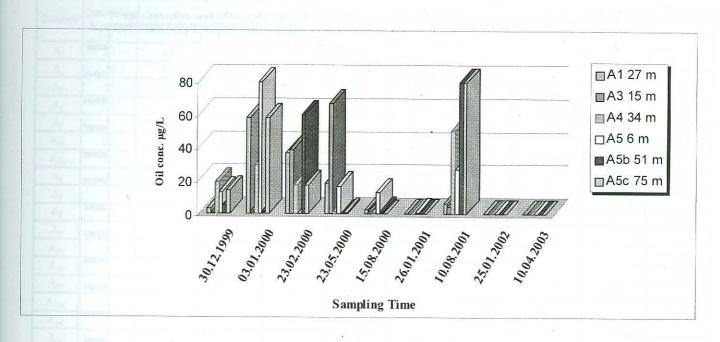


Figure 7. Graphical representation of oil pollution in deep water samples during the monitoring of 30.12.1999 – 10.04.2003.

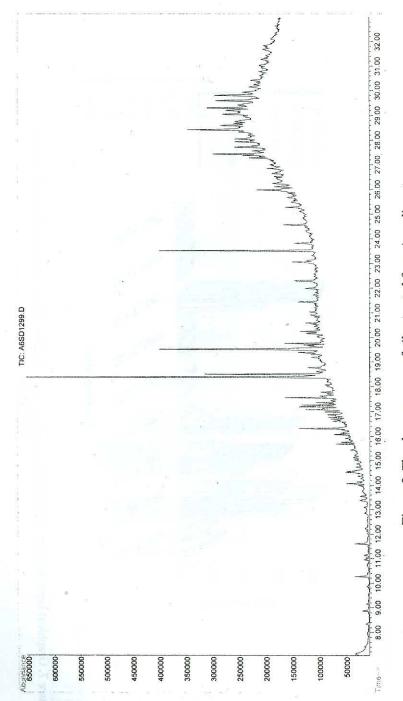


Figure 8. The chromatogram of oil extracted from A₆ sediment.

Table 4. The oil amount found of sediment in accident area $(\mu g/g)$ (wet weight).

-: No sampling

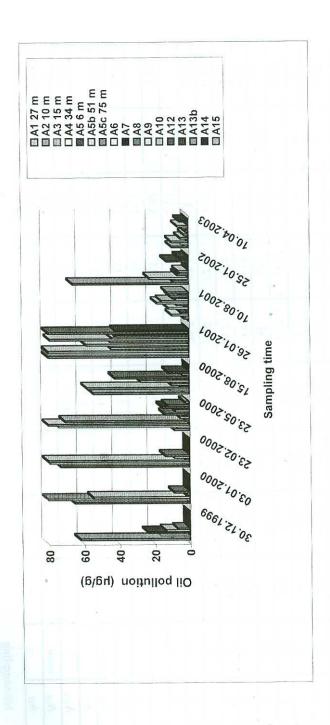


Figure 9. Graphical representation of oil pollution in sediment sample the stations during the monitoring of 30.12.1999 – 10.04.2003.

Discussion

As seen in Table 1 the petroleum component of Volganeft-248 with sea water sample taken after the accident in Florya side are similar.

According to fingerprinting findings, the cause of oil pollution in this area is belonging to VOLGONEFT 248 fuel oil.

After the accident the oil pollution was found in surface water of S_5 station as 14.05g/L on 29.12.1999. The classification of polluted seawater was 2.5 μ g/L through FAO (1982) and 5 μ g/L through Law (1981). The pollution value found belonging to Volganeft-248 accident is 2.8 million times higher than the limit value of 5 μ g/L at station S_3 . When the results are compared with the oil pollution levels of other accident; in the North Cape accident of Rhode Island (USA), 2700 tons of fuel oil had spilled into the sea. The amount found in sea water was 3.94-115 μ g/L (Reddy and Quinn, 1998). After Amoco Cadiz accident (1978), 30.000 tons of petroleum had spilled into the sea and the amount found in sea water was 2.7-240 μ g/L, (Law, 1978). The petroleum amount found in sea water after the VOLGONEFT-248 accident was S_5 station 14.05 g/L. Compared to previous accidents, the value indicates above for Volganeft-248 is a very high oil level pollution.

During the surveys, the oil pollution belonging to Volgoneft-248 were; at station S_2 450.0 $\mu g/L$ on 03.01.2000, 247.8 $\mu g/L$ on 15.08.2000, and 314.2 $\mu g/L$ on 26.01.2001, at station S_1 567.6 $\mu g/L$ on 10/08/2001. The differences of the pollution values between the stations as a function of time are depending on the dispersion of flocculated oil.

The oil pollution found in sediment was 441 $\mu g/g$ on 23.05.2000. The comparison of the pollution amount with the accident of Sea Empress (1996) where 130.000 tons of petroleum has spilled into the sea water and oil pollution in sediment determined was 36-86 $\mu g/g$ (Glegg et al.,1999). When the pollution value found in this accident compared with Florya-Küçükçekmece sediment the contamination level is very high in VOLGONEFT-248 accident.

40 months later the oil pollution has decreased to 0.94 μ g/L in seawater and to 9.6 μ g/g in sediment.

To prove the origin of the petroleum pollution in the examined area, the comparison was made by GC/MS on aliphatic and aromatic hydrocarbon content identified (Table 1) of VOLGONEFT-248 with the seawater samples similar petroleum components were found.

Finally the source of the oil pollution determined in the sea water and sediment in Florya and Küçükçekmece area is belonging to VOLGONEFT-248.

Özet

Bu çalışmada 29.12.1999 tarihinde Florya-Küçükçekmece sahilinde meydana gelen VOLGONEFT-248 tanker kazası sonrası petrol kirliliği 40 ay boyunca devamlı ve 2006 yılına kadar da aralıklı olarak incelenmiştir. Kaza sonrası deniz yüzeyi 5 cm kalınlıkta petrol kütlesi ile kaplı idi. Rüzgar ve dalgalar etkisi ile bu kirlilik sedimente yapışmış ve zaman zaman yüzeye çıkmıştır. Bunun sonucu olarak tayın boyunca kirlilik değerlerinde farklılıklar görülmüştür. Başlangıçta en yüksek kirlilik petrol için deniz suyunda verilen sınır değerin 2.8 milyon katı ve sediment için verilen sınır değerin 44.1 katı idi. Bu bölgede petrol kirliliği 40 ay sonra sınır değerin altına düşmüş ve 2006'ya kadar bu durum devam etmiştir. Bu analizler UVF ve GC/MS aletleri ile yapılmıştır. VOLGONEFT-248'e ait petrolün analizi ile deniz ve sedimentten alınan örneklerin analizlerinin karşılaştırılmasında bu kirliliğin VOLGONEFT-248'e ait olduğu ispatlanmıştır.

References

Boehm, P.D., Douglas, G.S., Burns, W.A., Mankiewiez, P.J., Page, D.S. and Bence, A.E. (1997). Application of petroleum hydrocarbon chemical fingerprinting and allocation techniques after the Exxon Valdez oil spill. Mar. Poll. Bull. 34: 599-613.

Food and Agricultural (FAO) (1982). The review of the health of the oceans. FAO/IMCO/Unesco/WMO/WHO/IAEA/Uneo Joint Group of Experts on scientific Aspects of Marine Pollution (Gesamp) Rep. Stud. Gesamp. 15:1008.

Glegg, G.A., Hickman, L., Rowland, S.J. (1999). Contamination of limpets (*Patella vulgata*) following the Sea Empress oil spill. *Mar. Poll. Bull.* 38: 119-125.

Law, R.J. (1978). Petroleum hydrocarbon analyses conducted following the wreck of the super tanker Amoco Cadiz. *Mar. Poll. Bull.* 9: 293-296.

Law, R.J. (1981). Hydrocarbon concentrations in water and sediments from UK marine waters, determined by fluorescence spectroscopy. *Mar. Poll. Bull.* 12: 153-157.

Reddy, C. and Quinn, J.G. (1998). GC-MS analysis of total petroleum hydrocarbons and polycyclic aromatic hydrocarbons in sea water samples after the North Cape oil spill. *Mar. Poll. Bull.* 38: 126-135.

Received: 27.01 .2006 Accepted: 28.02 .2006