Oil Pollution in Bosphorus, Golden Horn and Sea of Marmara after M/V GOTIA Ship Accident

M/V Gotia Gemi Kazası Sonrası İstanbul Boğazı, Haliç ve Marmara Denizindeki Petrol Kirliliği

Kasım Cemal Güven, Selma Ünlü, Kartal Çetintürk and Erdoğan Okuş

Istanbul University, Institute of Marine Sciences and Management, Muşkule Sokak 1. Vefa, 34116 Istanbul

Abstract
The GOTIA ship accident occurred on 06 Oct 2002 at Emirgan quay, in Bosphorus, 25 ton fuel was spilled into the sea. In this study the 279 samples of sea water, 6 mussel, 1 alg and GOTIA fuel oil were analysed by UVF and 287 samples by GC/MS and 200 samples by fingerprinting technique. The oil contamination was spread out at İstikyde, northern part of Bosphorus at Golden Horn and at Yenikapı (near south end of Bosphorus). The maximum oil levels found after the accident were 813.5 mg/L in Bosphorus is 7.3 mg/L in Golden Horn and 27.4 mg/L at Yenikapi. The oil pollution area related to GOTIA fuel oil was proved by using fingerprinting technique.

Keywords: Oil pollution, GOTIA ship accident, seawater, alga, mussel.

Introduction
Bosphorus (İstanbul Strait) is a narrow stretch of water separating Europe from Asia. There is a heavy traffic of shipping approx. 60.000 vessels per year involving tankers 10%. The most extensive research on the oil pollution in this strait was undertaken by our institute since 1994 following Nassia tanker accident.
Many accidents of merchant ships and tankers occurred in the strait. A comprehensive account on this subject was summarized by Akten (2003). The tanker accidents in Bosphorus are tabulated in Table 1.
Table 1. The tanker accidents occurred in Bosphorus and Sea of Marmara (after Akten 2003)

<table>
<thead>
<tr>
<th>Date</th>
<th>Vessel</th>
<th>Location</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.09.1964</td>
<td>Norborn (Norwegian) v. Peter Zoranic</td>
<td>18 000 tons oil spilled and fire</td>
<td></td>
</tr>
<tr>
<td>01.03.1996</td>
<td>Lutsk (USSR) v. Kransky Oktiabr (USSR)</td>
<td>1850 tons oil spilled</td>
<td></td>
</tr>
<tr>
<td>15.11.1979</td>
<td>Independenta (Romania) v. Evriali (Greek)</td>
<td>70 000 tons oil spilled and 20 000 ton oil burnt.</td>
<td></td>
</tr>
<tr>
<td>09.11.1980</td>
<td>Nordic Faith (British) v. Stavanda (Greek)</td>
<td>collision and fire</td>
<td></td>
</tr>
<tr>
<td>25.03.1990</td>
<td>Jambur (Iraqi) v. Da Tung Shan (Chinese)</td>
<td>2600 tons oil spilled</td>
<td></td>
</tr>
<tr>
<td>13.03.1994</td>
<td>Nassia (Philippines) v. Shipbroker (Philippines)</td>
<td>9 000 t oil was spilled and 20 000 t burnt</td>
<td></td>
</tr>
<tr>
<td>30.12.1999</td>
<td>Volgoneft (Russian)</td>
<td>1200 tons oil spilled (in Sea of Marmara)</td>
<td></td>
</tr>
<tr>
<td>06.10.2002</td>
<td>Gotia (Malta)</td>
<td>2 tons oil spilled.</td>
<td></td>
</tr>
</tbody>
</table>

v: wreck

The major accidents happened by the large tankers Independenta in 1979 and Nassia in 1994. M/V GOTIA sank into Bosphorus and 25 t fuel oil was spilled and pollution spread out into a large area by winds.

In this work, the oil pollution areas from GOTIA fuel spilt were determined in Bosphorus, in Golden Horn and at Yenikapi (Sea of Marmara).

**Material**
The sampling stations are shown in Fig. 1 and 2 and the dates were:

|------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------|

86
Figure 1. Sampling stations in the Bosphorus and the Marmara Sea
Figure 2. Sampling stations in the Golden Horn.
Sampling points: GK (Galata Bridge), UK (Unkapanı Bridge),
PK (Patríkane), BT (Balat), VS (Valide Sultan Bridge)

The samples are:
1- Sea water
Bosphorus: İstinye- Salıpazarı,
Golden Horn: Valide Sultan Bridge- Galata Bridge,
Sea of Marmara: Sarayburnu-Yenikapı.
2-Mussels (*Mytilus galloprovincialis* (L.))
Bebek inlet, Galatasaray adası, Sabancı Tesisı
3-Marine algae
Bebek inlet in Bosphorus

**Methods**

1-Standard equation

Oil determination was made by UVF and oil components were analysed by GC/MS. Oil pollution was determined by using GOTIA fuel oil as standard in a conc. of 0.6-1.8 µg/µl in hexane. The standard curve was plotted at 310/360nm (ex/em) in UVF (Shimadzu RF- 1501). The equation of standard curve was taken from the apparatus.

2-GC/MS oil analysis

The oil components were analysed by GC/MS on the samples and also GOTIA fuel.

GC/MS (HP 6890) analysis:
The GC column was an HP 5-MS 30 mx0.25mm i.d.(film thickness 0.25µm) fused- methyl siloxane (Hewlett-Packard). Injections (2µl) were conducted in the splitless mode with the column held at 50°C for 1 min, from 50-320°C for 10°C/min, 320°C at 5 min; the carrier gas helium (0.8 ml/min). The injector temperature was held at 300°C. Mass spectral data were acquired in Selected Ion Monitoring (SIM) mode.

2.1-Oil determination in seawater

Sea samples were extracted 3 times with 50 ml DCM. The extracts were dried over, anhydrous sodium sulfate then distilled at 35°C. The residue was taken with hexane and the volume adjusted to 10 ml and its intensity was measured in UVF and oil pollution levels was determined by using standard equation of GOTIA fuel oil.
2.2 – *Oil determination on mussel*

The oil contamination was determined in shell and inner part of mussel.

2.2.1- Shell part
40 g Mussel shell parts were washed with DCM and oil amount was determined as indicated in sea water.

2.2.2- Inner part
25 g Inner part was mixed with 20 g anhydrous sodium sulfate and extracted with DCM in soxhlet apparatus for 8 h. The extract was dried with anhydrous sodium sulfate then distilled at 35°C. The residue was taken with hexane and oil amount was determined as indicated in sea water.

2.3- *Oil determination in alga*

*Ulva rigida* sample was extracted in soxhlet with 200 ml DCM for 8h. The extract was dried with anhydrous sodium sulfate then filtered and distilled. The residue was taken with hexane and oil amount was determined as indicated in sea water.

3- *Fingerprinting analysis*

After determination of oil amount of the sample by UVF analysis the remaining part was hydrolysed with 2% NaOH/ ethanol under reflux in water bath. 50ml water was added on hydrolysate and re-extracted with pentane. Organic phase was distilled and residue was taken with hexane and analysed by GC/MS. Fingerprinting method was used for the identification of source of oil. The chromatograms were compared with GOTIA fuel oil chromatogram. Dibenzothiophene (DBT m/z 184.03 and it homologes C₁ (m/z 198.05) and C₂ (m/z .212.06)) were used to identify the origin of oil.
Results

1-UVF

1.1. The standard equation of GOTIA fuel oil is:

\[ F_1 : 693.3 \times C - 331.29 \quad r^2 : 0.999 \]

1.2. Sea water

The oil contamination in examined areas are shown in Tables 1, 2 and 3. The max. oil contamination was found on 19 Oct 2002 in Arnavutköy as 154.6 mg/L, in Bebek as 813.5 mg/L. The oil level was appreciably high at the various stations depending on wind direction. The highest contamination determined at the stations are:

in Bosphorus

<table>
<thead>
<tr>
<th>Station</th>
<th>Value (mg/L)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sabancı Tesisı</td>
<td>508.4</td>
<td>15 Oct 2002</td>
</tr>
<tr>
<td>Hisar</td>
<td>26.2</td>
<td>15 Oct 2002</td>
</tr>
<tr>
<td>Emirgan</td>
<td>30.9</td>
<td>19 Oct 2002</td>
</tr>
<tr>
<td>Baltalimanı</td>
<td>3.3-4.4</td>
<td>17-19 Oct 2002</td>
</tr>
<tr>
<td>Galatasaray adası</td>
<td>70.9</td>
<td>12 Oct 2002</td>
</tr>
<tr>
<td>Arnavutköy</td>
<td>154.6</td>
<td>10 Oct 2002</td>
</tr>
<tr>
<td>Bebek inlet</td>
<td>813.5</td>
<td>14 Oct 2002</td>
</tr>
<tr>
<td>(in beginning)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Istinye</td>
<td>58.3</td>
<td>19 Oct 2002</td>
</tr>
<tr>
<td>Ziya Kalkavan School of Marine</td>
<td>68.4</td>
<td>10 Oct 2002</td>
</tr>
<tr>
<td>DGM (Goverment Security Court) front</td>
<td>22.7</td>
<td>18 Oct 2002</td>
</tr>
<tr>
<td>Beşiktaş</td>
<td>0.3</td>
<td>14 Oct 2002</td>
</tr>
<tr>
<td>Dolmabahçe</td>
<td>1.3</td>
<td>20 Oct 2002</td>
</tr>
<tr>
<td>Sarayburnu</td>
<td>175</td>
<td>23 Oct 2002</td>
</tr>
</tbody>
</table>

in Golden Horn

<table>
<thead>
<tr>
<th>Station</th>
<th>Value (mg/L)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unkapanı Bridge</td>
<td>7.3</td>
<td>10 Oct 2002</td>
</tr>
<tr>
<td>In front of Patrikhane</td>
<td>0.6</td>
<td>21 Oct 2002</td>
</tr>
<tr>
<td>Balat</td>
<td>0-4</td>
<td>12 Oct 2002</td>
</tr>
<tr>
<td>Valide Sultan Bridge</td>
<td>0.4</td>
<td>16 Oct 2002</td>
</tr>
</tbody>
</table>

in Marmara Sea

<table>
<thead>
<tr>
<th>Station</th>
<th>Value (mg/L)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kumkapı</td>
<td>27.4</td>
<td>17 Oct 2002</td>
</tr>
<tr>
<td>Sarayburnu</td>
<td>175.0</td>
<td>23 Oct 2002</td>
</tr>
</tbody>
</table>
Table 1. The oil pollution levels (mg/L) in the sea water of the middle areas of Bosphorus after the GOTIA ship accident

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>BEBEK COVE</th>
<th>ARNAVUTKÖY</th>
<th>GALATASARAY ADAȘI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>entrance</td>
<td>Inlet inside</td>
<td>exit</td>
</tr>
<tr>
<td>10 Oct 02</td>
<td>188.2</td>
<td>-</td>
<td>0.30</td>
</tr>
<tr>
<td>12 Oct 02</td>
<td>9.9</td>
<td>0.30</td>
<td>-</td>
</tr>
<tr>
<td>14 Oct 02</td>
<td>6.20</td>
<td>813.5</td>
<td>9.50</td>
</tr>
<tr>
<td>15 Oct 02</td>
<td>0.07</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16 Oct 02</td>
<td>0.70</td>
<td>41.20</td>
<td>-</td>
</tr>
<tr>
<td>17 Oct 02</td>
<td>40.10</td>
<td>122.4</td>
<td>0.70</td>
</tr>
<tr>
<td>18 Oct 02</td>
<td>312.7</td>
<td>6.40</td>
<td>0.10</td>
</tr>
<tr>
<td>19 Oct 02</td>
<td>1.60</td>
<td>-</td>
<td>0.03</td>
</tr>
<tr>
<td>20 Oct 02</td>
<td>2.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>21 Oct 02</td>
<td>28.9</td>
<td>-</td>
<td>0.005</td>
</tr>
<tr>
<td>22 Oct 02</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>23 Oct 02</td>
<td>-</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>28 Oct 02</td>
<td>0.06</td>
<td>1.60</td>
<td>-</td>
</tr>
<tr>
<td>19 Dec 02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.008</td>
</tr>
</tbody>
</table>

*: surface completely covered with petroleum
-
*: No sampling
<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>İSTİNYE</th>
<th>EMİRGAN</th>
<th>BALTALIMANI</th>
<th>HISAR</th>
<th>SABUNCI TESİS</th>
<th>ORTAĞÖ</th>
<th>ZKDMYO</th>
<th>DGM</th>
<th>BEŞİKTAŞ</th>
<th>DOLMABAHE</th>
<th>SALİ PALAHI</th>
<th>KIZKULESİ</th>
<th>SARAY BURNU</th>
<th>KÜNKAPI</th>
<th>YENİKAPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Oct 02</td>
<td>-</td>
<td>0.01</td>
<td>0.07</td>
<td>2.50</td>
<td>-</td>
<td>0.05</td>
<td>68.4</td>
<td>*</td>
<td>0.001</td>
<td>-</td>
<td>0.60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12. Oct 02</td>
<td>-</td>
<td>0.40</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>0.02</td>
<td>0.30</td>
<td>-</td>
<td>0.01</td>
<td>0.05</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14. Oct 02</td>
<td>-</td>
<td>0.07</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>0.10</td>
<td>0.03</td>
<td>0.05</td>
<td>0.30</td>
<td>0.04</td>
<td>0.005</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15. Oct 02</td>
<td>-</td>
<td>0.02</td>
<td>0.05</td>
<td>26.2</td>
<td>508.4</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
<td>0.02</td>
<td>0.05</td>
<td>0.02</td>
<td>0.03</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>16. Oct 02</td>
<td>-</td>
<td>0.05</td>
<td>0.03</td>
<td>0.03</td>
<td>27.50</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>-</td>
<td>0.02</td>
<td>0.05</td>
<td>4.40</td>
<td>0.006</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>17. Oct 02</td>
<td>-</td>
<td>0.05</td>
<td>3.30</td>
<td>2.30</td>
<td>-</td>
<td>2.60</td>
<td>0.70</td>
<td>0.02</td>
<td>-</td>
<td>0.04</td>
<td>0.09</td>
<td>0.03</td>
<td>0.06</td>
<td>27.4</td>
<td>0.07</td>
</tr>
<tr>
<td>18. Oct 02</td>
<td>-</td>
<td>0.20</td>
<td>3.30</td>
<td>7.90</td>
<td>2.50</td>
<td>0.10</td>
<td>0.05</td>
<td>22.7</td>
<td>-</td>
<td>0.08</td>
<td>0.06</td>
<td>0.06</td>
<td>0.20</td>
<td>-</td>
<td>0.10</td>
</tr>
<tr>
<td>19. Oct 02</td>
<td>58.3</td>
<td>30.9</td>
<td>4.40</td>
<td>26.7</td>
<td>0.09</td>
<td>0.03</td>
<td>0.04</td>
<td>0.004</td>
<td>-</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>-</td>
<td>0.005</td>
</tr>
<tr>
<td>20. Oct 02</td>
<td>-</td>
<td>0.02</td>
<td>0.03</td>
<td>0.10</td>
<td>0.03</td>
<td>0.05</td>
<td>0.05</td>
<td>0.050</td>
<td>-</td>
<td>1.30</td>
<td>0.02</td>
<td>0.01</td>
<td>29.2</td>
<td>-</td>
<td>0.007</td>
</tr>
<tr>
<td>21. Oct 02</td>
<td>-</td>
<td>0.004</td>
<td>0.006</td>
<td>0.03</td>
<td>0.03</td>
<td>0.60</td>
<td>0.03</td>
<td>0.03</td>
<td>-</td>
<td>0.05</td>
<td>0.02</td>
<td>0.05</td>
<td>0.004</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>22. Oct 02</td>
<td>-</td>
<td>0.01</td>
<td>0.019</td>
<td>0.02</td>
<td>0.02</td>
<td>0.50</td>
<td>-</td>
<td>0.03</td>
<td>-</td>
<td>0.03</td>
<td>0.004</td>
<td>0.003</td>
<td>-</td>
<td>0.006</td>
<td>-</td>
</tr>
<tr>
<td>23. Oct 02</td>
<td>-</td>
<td>0.05</td>
<td>0.027</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>-</td>
<td>0.02</td>
<td>0.002</td>
<td>0.03</td>
<td>175.0</td>
<td>-</td>
<td>0.10</td>
</tr>
<tr>
<td>28. Oct 02</td>
<td>-</td>
<td>0.03</td>
<td>0.20</td>
<td>-</td>
<td>0.03</td>
<td>0.60</td>
<td>0.03</td>
<td>0.05</td>
<td>-</td>
<td>0.03</td>
<td>0.10</td>
<td>0.003</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19. Dec 02</td>
<td>-</td>
<td>0.006</td>
<td>0.03</td>
<td>-</td>
<td>0.01</td>
<td>0.02</td>
<td>0.006</td>
<td>0.006</td>
<td>-</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.005</td>
<td>-</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*: surface completely covered with petroleum
\:- No sampling
ZKDMYO: Ziya Kalkavan School of Marine, DGM: Goverment Security Court.
Table 3. Oil pollution levels (mg/L) in Golden Horn after the accident

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>Galata Bridge (GK)</th>
<th>Unkapanı Bridge (UK)</th>
<th>Front of Patrikhanı (PK)</th>
<th>Balat (BT)</th>
<th>Valide Sultan Bridge (VS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Oct 02</td>
<td>-</td>
<td>7.30</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 Oct 02</td>
<td>-</td>
<td>0.40</td>
<td>0.02</td>
<td>0.40</td>
<td>-</td>
</tr>
<tr>
<td>14 Oct 02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15 Oct 02</td>
<td>-</td>
<td>-</td>
<td>0.04</td>
<td>0.03</td>
<td>0.004</td>
</tr>
<tr>
<td>16 Oct 02</td>
<td>-</td>
<td>0.005</td>
<td>0.05</td>
<td>0.04</td>
<td>0.50</td>
</tr>
<tr>
<td>17 Oct 02</td>
<td>0.09</td>
<td>0.70</td>
<td>0.20</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>18 Oct 02</td>
<td>-</td>
<td>0.10</td>
<td>0.10</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>19 Oct 02</td>
<td>-</td>
<td>0.05</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>20 Oct 02</td>
<td>-</td>
<td>0.03</td>
<td>0.03</td>
<td>0.08</td>
<td>0.04</td>
</tr>
<tr>
<td>21 Oct 02</td>
<td>-</td>
<td>0.02</td>
<td>0.60</td>
<td>0.06</td>
<td>0.005</td>
</tr>
<tr>
<td>22 Oct 02</td>
<td>-</td>
<td>0.05</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>23 Oct 02</td>
<td>-</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>28 Oct 02</td>
<td>-</td>
<td>0.005</td>
<td>0.01</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>19 Dec 02</td>
<td>0.01</td>
<td>0.07</td>
<td>0.01</td>
<td>0.003</td>
<td>0.03</td>
</tr>
</tbody>
</table>

No sampling

Before the GOTIA accident, oil pollution level in the Bosphorus are 0.05 mg/L (Güven et al., unpublished data). According to these data the oil contamination due to GOTIA ship accident is 16260 times as high for 2002 oil pollution results in this area.

1.3. Mussel Samples

The oil amount found in mussel (shell and inner part) are shown in Table 4.

Table 4. The oil pollution level in the mussel samples

<table>
<thead>
<tr>
<th>Sampling date</th>
<th>Station</th>
<th>Examined part</th>
<th>mg/g (wet weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 Oct 02</td>
<td>Galatasaray adası</td>
<td>inner</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Bebek</td>
<td>inner</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Sabancı Tesisı</td>
<td>shell</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>inner</td>
<td>0.02</td>
</tr>
<tr>
<td>23 Oct 02</td>
<td>Bebek</td>
<td>shell</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>inner</td>
<td>0.20</td>
</tr>
</tbody>
</table>

The highest oil contamination was found in Galatasaray adası as 0.30mg/g in flesh. The oil contamination of the mussel collected
after Nassia Tanker accident in 1994-1995 was 5-250 μg/g (Güven et al., 1995). This result showed that the oil contamination is 60-125 times higher than the of Nassia Tanker accident.

1.4. Alga
The oil contamination in Ulva rigida was 179 mg/g on 23 Oct 2002 (Table 5).

Table 5. The oil pollution level in alga (Ulva rigida)

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>Station</th>
<th>mg/g (Wet weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 Oct 02</td>
<td>Bebek</td>
<td>0.20</td>
</tr>
</tbody>
</table>

When the results of oil pollution on the algae following the GOTIA tanker accident on 06 Dec 2002 are compared with those obtained earlier (in 1995) from Bosphorus it is apparent that the pollution on the algae due to the accident increased 100 times.

2. GC/MS Results

The total GC chromatogram of GOTIA fuel oil and the samples are shown in Figure 3, 4, 5. A n-alkane sequence were detected in samples collected from sea water at all stations in the Bosphorus. Pristane and phytane (Pr/Ph) ratio calculated is 0.62. Meanwhile the unresolved complex mixture (UCM) is observed in all chromatograms. The findings of n-alkane sequence, Pr/Ph ratio and UCM hump (indicate fresh pollution) shown that the pollution is GOTIA fuel oil. The same oil components were in all the samples examined by GC/MS analysis.
Figure 3. GC/MS chromatogram of GOTIA fuel oil

Figure 4. GC/MS chromatogram of sea water from Arnavutköy

Figure 5. GC/MS chromatogram of sea water from Kumkapı
The fingerprinting of GOTIA fuel oil and the samples collected Bosphorus Golden Horn and Marmara Sea are shown in Figure 6-12. All the chromatogram of fingerprinting are the same with GOTIA fuel oil.

Figure 6. The fingerprints of GOTIA fuel oil

Figure 7. The fingerprints of sea water sample from Bebek Cove
Figure 8. The fingerprints of sea watersample from Istinye

Figure 9. The fingerprints of sea watersample from Sarayburnu

Figure 10. The fingerprints of sea watersample from Kumkapi
Figure 11. The fingerprints of sea water sample from Golden Horn (Valide Sultan Bridge)

Figure 12. The fingerprints of sea water sample from Yenikapi

Discussion

The comparison of oil pollution due to spill after major tanker accidents worldwide is:

Tsесi$: Stockholm, Sweeden 1977  17 575 t fuel oil spilled and levels of 50 ppb were measured in the spill path (Johansson et al., 1980).
Exxon Valdez: Alaska, U.S.A. 1989, 9330000t oil spilled, pollution level on sea; 6.24 μg/L (Boehm et al., 1997; Rice et al., 1996).

Amoco Cadiz: in Brittany, France 1978, 221 000t oil spilled, pollution level on sea; 100μg/L (Marchand, 1980; Dauvin, 1998).


The Braer accident in Shetland, 85 000 tonnes of oil spilled levels reaching as much as 5000 ppb in the immediate vicinity of the wreck and over 1000 ppb in other inshore areas (Newey and Seed, 1995).

After the 1991 Gulf War 6800 t oil spill and remained on the sea surface, 161.6 mg/m² (Sen Gupta et al., 1993), 10 816 700 barrels oil released Tawfiq and Olsen (1993) (oil from fires unknown) and it was over 40 times larger than the Exxon Valdez Spill (Michel et al., 1993; Shridah, 1998; Mostafawi, 2001).

Independenta accident (1979) in Haydarpaşa (Sea of Marmara) when 94 600 tons oil spilled and fire, pollution undetected.

Nassia tanker accident in Sarıyer (1994) when 9000 tons oil of spilled and 20 000 tons oil fired. The highest pollution level was found as 24.9 μg/L in surface water (Güven et al., 1996).

TPAO tanker accident (1997) in Tuzla (Marmara Sea) 214.3 ton oil was spilled and 250 ton oil burnt. The highest pollution level was found as 33.2mg/L in sea water (Ünlü et al., 2000).

The pollution level of sea which we found after the GOTIA accident in Bosphorus in 2002 seems to be the highest when compared with the figures indicated above for the major tanker accidents in the World and also specifically with those in the main straits. It is the highest ever contamination recorded according to the data given in the literature.

Özet

En yüksek kirlilik miktarları Boğaziçi'nde Arnavutköy de 813.5 mg/L., Haliçte 7.3 mg/L ve Marmara Denizi Yenikapıda 27.4 mg/L olarak bulunmuştur. Bu kaza sonrası deniz kirliliği 1 sene takip edilmiş kirliliğin normal boyutlara indiği saptanmıştır.

References


*Received: 08-10-2003*  
*Accepted: 26-12-2003*