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Oil pollution level in sea water and sediments of Turkish Straits (Bosphorus, Sea of Marmara, Dardanelles) and Golden Horn during 2004-2007

Türk Boğazlar Sistemi (İstanbul Boğazı, Marmara Denizi, Çanakkale) ve Haliç'te su ve sedimentte 2004-2007 arasında petrol kirliliği

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Abstract

In this paper oil pollution levels were determined in sea water and sediments of Turkish Straits (Bosphorus, Sea of Marmara, and Dardanelles) and additionally Golden Horn during 2004-2007. Oil concentrations were varied in examined area. The highest oil levels found in sea water were: in 2004 in Bosphorus B7 at 10 m depth 1512.73 µg/l, in 2005 at K0 therm., 3173.67 µg/l, in 2006 at KK 1307.55 µg/l and in 2007 at B13 therm., 1243.61µg/l. The highest oil amount found in sediments were: in 2004 in Sea of Marmara at MKC 1238.40 µg/g, in 2005 at MK 2763.76 µg/g, in 2006 at MK 1859.10 µg/g.

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The cause of high pollution levels is: for Bosphorus heavy ship traffic, for Sea of Marmara illegal discharge of ballast water from tankers came to Izmit refinery and sewage of urban/industrial water and for Golden Horn heavy boats traffic. It was observed in some stations a relationship on pollution levels between sea water and sediment.

Key words: Bosphorus, Golden Horn, Sea of Marmara, Dardenelles, oil pollution.

Introduction

Turkish straits are composed as Istanbul Strait (Bosphorus), Sea of Marmara and Çanakkale Strait (Dardanelles). Istanbul Strait is about 35 km in length 1.4 km width and its narrowest part (İstinye-Kandilli) 720 m. The deepest point 110 m. Two currents exist in the Turkish straits including the upper layer is Black Sea water (0.5-4.8 knots) undercurrent is Mediterranean water (1.6 knots). The Sea of Marmara is 11.500 km^2, 276 km in length (Gelibolu-İzmit) and 76 km width. The deepest point is 1335 m. Çanakkale Strait is 60 km long and 6.5 km width and 1.2 km narrowest part. The depth is varying between 60-100 m. Golden Horn is a narrow inlet of the Bosphorus. It is 8 km long and 200-700 m wide the deep is between 1-40 m.

The oil pollution of sea water is an important problem especially for its toxicity on marine organisms and being a cover on surface water preventing the penetration of oxygen into sea water. Oil enters the seas in different ways as shipping, industrial activities, transport of oil by tankers, refinery, atmosphere and natural sources. The ratio of oil input are(%): 50 industrial influent urban/river, rain, 19 shipping operations, 13 atmospheres, 11 natural sources, 5 tanker accidents (Annon 1993).

Oil on the surface water is easily detected when it is in a sufficient quantity. The crude oil is commercially classified by its density and sulfur content as light, medium and heavy. The difficulty on the determination of oil quantity exists because the crude oil composition changes depending on the origin.

Oil pollution literature on this area are summarized as in sea water and sediment of Bosphorus and Sea of Marmara (Sakarya 1982), in Istanbul Strait (Baştürk et al. 1988, Shimkus et al. 1993), Güven et al. (1995), Okuş et al. (1996, 2007), Güven et al. (1996, 1997, 1998, 2000, 2002a,b, 2003a,b, 2004, Günday et al. (2006), Cumalı and Güven (2008).

The present study was undertaken to determine of oil pollution in sea water and sediments of Istanbul Strait (Bosphorus), Haliç (Golden Horn), Sea of Marmara and Çanakkale Strait (Dardanelles) between 2004-2007.

Material and Methods

Sea water sampling and analyses

Sea water samples (3.5 l) were taken by Nansen apparatus containing 10 ml dichloromethane. It was divided into 3x800 ml and each portion was extracted 3 times with 3x30 ml of dichloromethane, the extracts were combined and dried over anhydrous sodium sulfate, filtered and distilled at 40^{o}C. The residue was dissolved in hexane and the volume adjusted to 10 ml with hexane. The oil concentration was measured by UV Fluorospectrophotometer (Shimadzu RF-1501).

Sediment sampling and analyses

The sediment samples were taken by van Veen grab, at depths indicated 6 and it was stored in deep freeze at -20^{o}C until the analyses.

Sediment sample (20 g) was mixed with 40 g of anhydrous sodium sulfate and extracted with the dichloromethane in a Soxhlet apparatus for 8 h. The extract was dried over anhydrous sodium sulfate then filtered and distilled at 40^{o}C. The residue was taken with hexane and the volume was adjusted to 10 ml in a volumetric flask. The oil concentration was determined by UV Fluorospectrophotometer.

Standard equation of oil

Reference materials used are Russian crude oils obtained from TUPRAŞ refinery (Izmit/Turkey). The standard curves were plotted with a

concentration of 0.25-1.25 µg/ml in hexane and fluorescence intensity was measured at 310/360 nm (ex/em) by UV Fluorospectrophotometer (Shimadzu RF 1501).

Chemicals: Hexane, dichloromethane and anhydrous sodium sulphate were obtained from Merck (Darmstadt, Germany).

Sea water sampling stations and dates are:

Istanbul Strait: in 2004-2007 each month at K0, K0(A),K0(B), B13, B7, B2, KK

Golden Horn: in 2004-2007 each month at Adalar Sonrası, Eyüp Sütlüce, Haliç Bridge, Valide Sultan Bridge, Unkapanı Bridge, Galata Bridge

Sea of Marmara

a) North part: in 2004-2007 each month in the years: at M3, M8, M11, M14, M20, M23, MBC, MKC, MKD, MK, MY2, MY1.
b) North and south part: in June, September, November 2005 and March 2006: at M3, M8, M11, M14, M20, M23, MD11A, MD13A, MD14, MD56, MD59, MD63, MD72,MD73, MD86, MD87, MD89, MK, MY1, MY2, MBC, MKC, DD1, IZ5C, IZ8, IZ17, IZ25, IZ30, SD1.

Çanakkale Strait: in June, September, November 2005 and March 2006 at D1, D3, D5, D7.

Sediment sampling stations and the date are Bosphorus K= in 2004-2005 each month, in 2006 Jan-Jun.

The locations of the stations are shown in Figure 1 and 2.

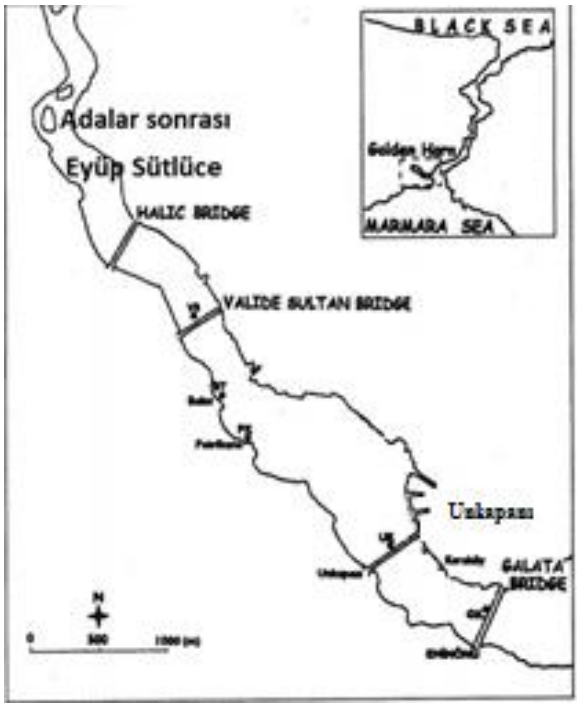

Figure 1. Sampling stations of Golden Horn

Results and Discussion

1. Oil contamination levels in sea water

Oil pollution level in 2004 and 2007 of Istanbul Strait and 2005-2006 in Sea of Marmara are listed in Table 1 - 5.

Figure 2. Sampling stations of Bosphorus, Sea of Marmara and Dardanelles.

Table 1. Oil pollution level in 2004 of Bosphorus, Golden Horn and Sea of Marmara (μg/L)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
K0	Surface	108.30	39.22	2.57	15.78	51.23	83.89	130.51	2.46	2.50	7.04	57.34	5.67
	10 m	103.96	46.23	2.12	11.69	47.89	54.50	1.67	3.53	2.71	4.88	12.04	38.14
	Therm	98.00	53.64	2.93	11.33	44.33	84.20	1.66	137.72	6.17	9.67	5.26	11.47
	Deep	113.47	85.32	3.01	173.9	40.73	80.41	2.25	3.45	2.34	5.85	9.77	13.03
KO(A)	Surface	84.93	37.82	0.90	19.19	70.02	42.02	2.69	7.95	3.01	7.37	4.44	12.54
	10 m	91.17	20.42	41.66	19.46	27.43	49.90	14.84	5.15	2.72	3.53	8.86	401.82
K0(B)	Surface	87.07	24.4	1.56	23.80	22.20	32.39	2.18	2.52	2.64	5.12	9.44	40.8
	10 m	84.43	65.17	1.00	27.39	19.76	52.47	2.04	9.18	2.72	5.85	17.82	44.45
B13	Surface	5.25	36.01	2.57	16.93	24.14	56.31	11.29	3.59	2.01	3.99	9.99	31.80
	10 m	84.96	37.6	2.57	13.64	36.94	71.01	2.35	3.46	2	9.11	9.11	26.69
	Therm	95.60	36.2	-	25.40	38.85	63.41	55.19	3.26	3.85	2.31	9.39	176.04
	Deep	97.05	39.4	1.74	12.52	35.07	55.93	3.06	23.63	2.69	4.31	10.59	382.5
B7	Surface	81.70	69.88	2.66	15.44	33.45	75.49	3.02	3.42	2.53	6.69	12.27	31.19
	10 m	89.15	38.37	2.44	25.91	41.10	78.47	3.35	166.53	1.89	4.7	10.94	1512.73
	Therm	92.99	81.14	3.34	23.26	36.27	98.43	4.8	3.44	1.36	6.09	13.24	406.91
	Deep	83.49	113.6	2.17	17.89	56.84	78.16	2.63	3.17	3.24	16.53	17.1	17.93
B2	Surface	125.35	54.17	3.04	28.72	50.77	49.37	2.62	4.46	1.92	3.46	7.66	1223.06
	10 m	97.73	58.39	3.44	22.26	44.35	52.05	2.75	10.09	2.01	5.42	8.65	304.7
	Therm	87.03	38.58	3.11	22.79	28.14	53.86	2.66	4.93	2.21	7.00	17.68	121.38
	Deep	83.73	84.26	2.66	20.64	24.01	78.43	2.37	4.84	2.28	6.76	27.39	13.86
KK	Surface	141.93	66.30	4.20	16.47	63.03	60.07	22.22	3.01	1.91	2.52	11.78	1182.65
	10 m	89.10	58.60	3.16	27.61	38.89	65.63	2.81	4.52	2.13	3.54	9.31	82.22
	Deep	113.39	180.6	3.29	32.40	30.81	69.98	2.45	3.78	2.78	6.55	6.83	146.98

Table 1. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Adalar S.	Surface	99.12	85.73	7.75	31.18	46.13	169.8	34.43	28.92	8.8	17.25	37.77	249.62
	Deep	215.38	86.24	31	33.18	51.59	162.4	11	27.7	12.84	61.84	382.53	248.91
Eyüp-Sütlüce	Surface	74.5	92.23	4.45	29.78	35.88	76.76	12.9	20.76	9.75	5.93	17.37	43.28
	Deep	111.54	62.29	1.22	37.22	34.51	83.15	10.15	34.16	5.78	7.96	68.36	22.68
Haliç Bridge	Surface	83.99	97.91	1.19	46.84	31.43	152.9	7.59	14.55	2.95	9.31	24.87	23.02
	Deep	90.14	51.04	13.29	27.56	42.28	93.82	10.31	19	4.59	11.26	20.68	20.61
V.Sultan Bridge	Surface	74.57	66.41	2.13	21.2	30.15	100.23	6.65	15.8	4.22	8.2	20.44	23.12
	Deep	8.41	43.48	0.94	23.73	13.78	106.2	7.88	35.7	2.97	19.87	30.56	23.79
Unkapanı Bridge	Surface	61.85	70.81	152.9	18.26	35.96	46.62	4.52	4.42	2.04	5.05	15.17	14.19
	10 m	85.33	63.36	28.9	21.95	53.23	44.43	3.27	3.45	2.58	5.37	9.18	21.72
	Therm	81.04	52.12	0.86	13.21	30.29	52.14	3.96	5.87	1.1	4.39	18.33	9.34
	Deep	84.49	73.88	7.19	13.99	34.03	41.84	3.55	12.41	6.22	96.22	14.34	9.09
Galata Bridge	Surface	101.51	60.34	1.25	6.48	25.55	72.26	4.6	28.94	2.04	5.35	16.01	30.02
	10 m	93.51	98.94	1.7	114.1	12.71	88.2	3.55	4.68	2.1	78.41	12.61	16.15
	Therm	109.02	60.93	17	32.63	28.37	57.38	2.89	37.29	1.34	6.02	92.82	7.4
	Deep	98.09	82.74	2.3	77.75	16.49	85.42	4.4	3.74	2.44	9.35	17.17	11.08
MY1	Surface	204.78	75.66	-	75.47	25.63	68.5	2.21	4.34	2.8	19.26	9.23	300.96
	10 m	75.55	74.73	-	20.63	26.25	54.68	1.74	10.78	3.37	6.58	7.92	76.28
	Therm	96.45	91.18	-	14.06	31.44	58.12	3.16	6.43	0.99	5.92	9.08	13.87
	Deep	183.02	61.28	2.55	13.52	30.54	66.75	1.9	3.6	1.23	4.48	7.74	31.64
MY2	Surface	96.23	63.36	6.27	13.15	70.63	99.7	2.62	13.17	4.03	4.81	110.78	17.99
	10 m	169.75	165.53	4.39	17.52	50.57	109.8	1.76	3.46	2.32	20.7	82.5	44.42
	Therm	180.33	74.46	3.5	23.4	65.62	111.3	1.74	5.33	2.3	2.25	6.71	37.11
	Deep	207.26	89.71	3.18	24.55	68.93	99.6	2.19	8.79	1.63	2.42	9	325.32

Table 1. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
M3	Surface	-	94.62	-	-	54.62	-	-	2.70	-	-	5.82	-
	10 m	-	100.20	-	-	55.33	-	-	2.69	-	-	11.26	-
	Therm	-	-	-	-	105.8	-	-	2.68	-	-	7.69	-
	Deep	-	113.76	-	-	64.23	-	-	2.04	-	-	12.03	-
M8	Surface	-	321.31	-	-	26.07	-	-	2.32	-	-	12.15	-
	10 m	-	79.19	-	-	34.76	-	-	8.29	-	-	12.52	-
	Therm	-	65.39	-	-	19.53	-	-	3.47	-	-	4.65	-
	Deep	-	86.86	-	-	27.31	-	-	5.14	-	-	4.37	-
M11	Surface	-	1.38	-	-	32.95	-	-	27.21	-	-	10.05	-
	10 m	-	3.15	-	-	39.67	-	-	11.63	-	-	11.52	-
	Therm	-	12.08	-	-	38.87	-	-	4.34	-	-	32.75	-
	Deep	-	5.03	-	-	54.76	-	-	2.46	-	-	88.16	-
M14	Surface	-	70.44	-	-	70.80	-	-	3.21	-	-	10.14	-
	10 m	-	67.61	-	-	56.70	-	-	3.58	-	-	8.23	-
	Therm	-	77.44	-	-	72.39	-	-	16.40	-	-	7.82	-
	Deep	-	150.15	-	-	78.16	-	-	2.45	-	-	5.70	-
M20	Surface	-	66.88	-	-	51.02	-	-	2.84	-	-	8.26	-
	10 m	-	68.14	-	-	160.00	-	-	2.85	-	-	7.72	-
	Therm	-	67.81	-	-	30.06	-	-	3.22	-	-	21.03	-
	Deep	-	81.83	-	-	47.35	-	-	2.87	-	-	7.77	-
M23	Surface	-	61.63	-	-	24.70	-	-	7.49	-	-	15.87	-
	10 m	-	57.54	-	-	33.76	-	-	1.93	-	-	11.67	-
	Therm	-	69.64	-	-	52.43	-	-	2.26	-	-	13.37	-
	Deep	-	84.88	-	-	40.63	-	-	2.13	-	-	10.29	-

Table 1. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
MK	Surface	209.63	88.89	3.9	30.43	45.62	57.99	1.98	112.15	2.39	1.69	15.2	4.99
	Deep	88.12	98.22	4.05	36.45	16.56	70.05	197.13	12.26	20.17	3.09	17.85	374.45
MKC	Surface	189.91	83.98	8.2	5.65	83.35	50.93	2.9	11.85	4.85	2.79	7.7	28.49
	10 m	113.878	64.6	3.77	41.67	48.65	27.36	2.02	22.84	2.8	3.07	11.19	10.78
	Therm	253.17	-	-	-	-	-	-	-	11.4	-	-	-
	Deep	216.03	79.74	2.43	85.78	68.72	44.73	1.66	3.22	-	3.08	8.56	17.91
MBC	Surface	78.24	88.38	3.02	7.99	42.43	67.05	2.32	2.65	3.18	2.79	11.4	25.62
	10 m	122.45	118.49	0.02	6.76	71.58	86.34	2.17	3.04	7.43	6.37	20.18	27.28
	Therm	95.86	450.22	18.1	6.26	60.38	41.63	1.6	2.3	2.7	3.29	23.41	23.79
	Deep	57.86	74.04	3.56	5.74	55.21	39.55	3.13	5.67	2.68	3.05	34.97	38.05

Table 2. Oil pollution level in 2005 of Bosphorus, Golden Horn and Sea of Marmara (μg/L)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
K0	Surface	7.03	3.79	2.46	3.09	8.08	2.28	9.19	1.51	1.67	292.98	75.38	62.93
	10 m	10.04	3.15	2.00	2.22	10.78	6.71	10.81	6.19	2.41	339.74	177.26	10.35
	Therm	1.56	3.34	1.57	1.93	10.39	18.03	4.27	1.87	2.64	2281.13	79.44	14.71
	Deep	13.86	3.03	5.60	3.78	17.62	19.22	98.23	2.90	2.82	3173.67	36.48	10.67
K0(A)	Surface	9.93	3.10	2.93	16.58	2.74	4.47	2.77	2.84	4.13	94.63	41.37	25.80
	10 m	2.76	3.72	2.85	2.17	9.27	2.54	2.87	1.67	2.93	111.86	36.64	61.52
K0(B)	Surface	28.41	4.06	3.79	16.58	3.36	14.34	0.36	3.47	2.26	160.88	32.59	47.08
	10 m	12.88	2.58	8.52	2.17	1.49	2.82	3.00	1.47	3.40	149.12	48.9	14.94
B13	Surface	23.30	6.01	7.98	14.45	2.23	4.74	3.58	1.27	4.67	61.23	70.57	14.44
	10 m	7.57	3.95	14.23	2.01	3.46	3.76	5.38	1.40	2.43	60.74	68.30	58.02
	Therm	21.26	3.64	113.91	2.74	3.20	7.31	2.91	1.59	2.22	54.08	63.84	18.66
	Deep	19.30	3.06	4.84	2.43	5.81	3.83	4.47	2.56	5.70	87.51	86.34	11.85
B7	Surface	11.02	4.37	1.92	8.27	17.45	2.13	52.88	11.59	2.70	120.44	35.63	111.77
	10 m	10.15	3.16	2.87	9.73	15.19	1.87	6.24	5.55	4.23	132.65	38.14	13.25
	Therm	11.34	4.53	3.80	4.36	13.49	3.62	8.09	3.94	4.05	66.82	45.09	10.57
	Deep	15.47	3.85	3.78	24.29	36.15	3.86	17.52	3.99	4.96	82.29	83.72	60.08
B2	Surface	9.14	3.21	2.50	8.81	10.19	4.20	5.25	1.35	12.04	63.49	75.99	40.78
	10 m	6.89	5.44	1.70	1.07	10.72	1.72	1.92	1.68	2.65	55.27	149.11	9.30
	Therm	11.82	3.69	2.59	1.92	19.93	6.89	5.69	2.73	3.00	-	33.85	30.87
	Deep	19.59	18.86	1.10	11.12	19.4	9.18	1.68	4.05	3.81	55.62	83.25	12.58
KK	Surface	22.42	2.10	2.31	1.8	2.33	4.10	3.30	1.42	4.64	85.72	48.46	13.59
	10 m	14.29	0.38	2.55	2.68	3.39	1.47	2.40	2.90	3.41	93.85	72.27	188.12
	Deep	17.55	3.64	1.78	1.97	3.45	17.49	28.76	2.44	4.95	183.58	31.46	16.83

Table 2. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
KK coast	Surface	-	-	-	-	21.01	5.01	10.63	2.17	3.30	77.17	71.43	15.48
	10 m	-	-	-	-	16.60	10.45	4.76	3.21	2.17	56.61	49.83	17.11
KK medium	Surface	-	-	-	-	8.36	3.66	8.44	2.01	3.35	57.89	78.93	13.00
	10 m	-	-	-	-	6.91	4.76	2.68	1.95	2.99	71.71	52.85	26.08
Adalar S.	Surface	104.46	11.01	17.83	25.67	34.51	33.52	34.04	11.94	48.6	222.18	708.54	166.37
	Deep	78.12	110.25	12.51	23.43	16.90	40.14	99.33	0.85	122.59	1671.57	1543.97	181.48
Eyüp-Sütlüce	Surface	12.23	53.89	1.70	16.34	10.72	31.27	52.91	18.65	32.12	58.99	280.86	67.45
	Deep	11.12	13.27	21.73	15.72	11.35	40.39	118.60	16.25	32.25	85.29	233.15	8.06
Haliç Bridge	Surface	47.55	26.65	6.25	2.65	8.48	16.67	13.79	9.74	31.00	169.94	366.21	41.98
	Deep	54.27	8.51	4.62	7.33	7.93	27.47	6.22	3.58	49.13	197.9	310.76	60.17
V.Sultan Bridge	Surface	17.40	3.73	2.37	2.96	8.34	20.98	35.33	11.38	18.01	153.05	518.04	49.08
	Deep	10.71	3.74	4.41	10.56	7.15	28.77	28.43	35.91	61.00	79.55	257.89	59.05
Unkapanı Bridge	Surface	4.57	189.90	4.02	1.16	5.75	19.17	87.76	2.49	66.58	62.64	71.55	53.34
	10 m	6.90	3.49	3.03	0.65	5.14	4.32	51.24	2.54	36.12	61.51	82.12	40.24
	20 m	3.41	2.09	5.27	11.66	3.39	7.13	13.71	8.86	4.21	53.64	80.29	45.01
	Deep	22.58	3.94	5.41	10.03	6.29	5.78	36.97	0.67	5.01	86.19	69.00	78.73
Galata Bridge	Surface	18.59	5.41	81.04	3.63	6.96	9.41	24.66	16.60	4.72	138.17	261.81	32.25
	10 m	26.52	2.90	3.67	1.79	3.54	3.66	205.58	4.25	3.18	1063.82	713.87	94.67
	20 m	4.99	1.91	2.19	0.70	5.91	4.11	22.93	5.10	3.92	475.20	272.75	15.60
	Deep	6.72	2.63	5.08	2.25	4.08	4.03	25.01	13.36	4.96	102.36	497.53	39.74
MK	Surface	22.54	6.52	3.43	1.21	12.61	2.40	3.28	6.14	17.18	83.02	1309.15	42.46
	Deep	17.91	2.83	3.35	2.37	8.94	8.81	9.21	5.56	11.09	84.98	112.79	43.60

Table 2. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
MY2	Surface	5.50	4.85	9.42	1.90	8.87	8.14	3.48	2.04	2.19	54.09	41.54	18.62
	10 m	7.37	2.39	3.13	0.90	3.27	3.63	2.76	1.75	1.98	68.73	57.98	42.29
	Therm	8.24	2.13	1.40	0.96	7.37	3.08	3.68	2.38	3.76	95.04	42.10	10.39
	Deep	8.73	3.91	5.04	6.43	2.05	9.10	4.27	1.76	3.25	51.80	54.19	4.94
MY1	Surface	13.13	3.20	12.91	1.37	3.45	18.17	7.65	4.59	3.09	72.65	89.32	35.56
	10 m	26.35	1.50	3.28	1.32	18.13	7.27	79.5	2.29	6.34	79.13	98.89	12.85
	Therm	18.24	4.10	5.62	5.37	6.22	10.5	222.95	1.65	4.05	109.6	78.92	11.41
	Deep	24.94	1.67	3.30	1.37	2.09	9.61	234.73	3.68	4.53	76.26	88.03	56.62
MKC	Surface	65.70	4.28	6.87	3.12	6.86	6.46	6.87	1.25	2.84	143.38	71.08	270.42
	10 m	11.06	4.11	2.36	1.66	3.08	3.46	6.53	2.72	2.01	60.45	99.03	14.72
	Therm	-	-	-	-	-	-	-	-	-	-	-	-
	Deep	28.49	17.88	1.66	1.23	7.76	10.71	2.10	3.32	2.79	69.25	89.60	17.10
MBC	Surface	6.87	2.69	6.91	1.25	2.69	25.64	3.27	1.65	3.24	73.35	684.27	34.50
	10 m	7.45	3.56	31.65	0.95	2.30	26.85	2.24	1.91	1.97	93.54	82.46	38.27
	Therm	5.98	2.14	2.74	12.72	2.85	19.33	8.08	1.92	36.84	51.37	62.27	42.29
	Deep	6.82	2.45	2.95	1.45	4.54	3.83	2.45	3.30	12.82	69.98	91.88	10.22

Table 3. Oil pollution level in 2006 of Bosphorus, Golden Horn and Sea of Marmara (μg/L)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
K0	Surface	29.45	34.21	-	271.26	243.49	130.96	155.75	53.42	53.64	32.93	23.1	79.24
	10 m	54.25	24.28	-	46.7	59.74	110.73	97.83	38.79	99.9	24.89	17.05	25.23
	Therm	83.82	14.09	-	43.96	54.26	376.05	47	82.41	91.32	29.71	26.33	29.81
	Deep	36.26	25.91	-	21.32	66.52	76.92	61.11	37.9	74.35	29.46	19.92	422.28
KO(A)	Surface	65.5	39.84	-	31.63	101.13	161.23	151.05	89.27	43.17	59.18	19.25	34.08
	10 m	65.84	56.27	-	35.73	80.91	73.95	83.29	36.39	70.79	57.19	23.61	38.49
K0(B)	Surface	70.06	25.59	-	47.44	71.35	89.39	3.73	85.6	43.23	69.6	19.89	24.45
	10 m	46.98	48.03	-	27.61	97.62	98.86	44.37	71.61	47.36	100.96	31.2	62.79
B13	Surface	34.88	31.45	-	56.94	100.74	85.34	51.6	42.42	50.85	48.65	54.34	31.95
	10 m	31.77	58.09	-	303.07	98.68	93.7	54.01	43.78	52.44	45.39	55.95	44.32
	Therm	74.2	51.26	-	55.68	113.32	120.31	88.58	87.66	69.67	52.61	128.82	67.05
	Deep	13.8	61.5	-	222.35	59.07	109.81	68.72	70.3	71.31	84.34	73.71	28.8
B7	Surface	36.81	47.22	-	44.88	52.66	103.49	158.26	66.75	29.36	33.47	49.3	40.48
	10 m	121.69	46.35	-	44.3	67.02	66.8	85.49	79.98	34.62	47.4	49.99	25.8
	Therm	88.38	39.94	-	40.64	91.81	52.37	124.17	75.91	34.99	40.74	64.15	28.32
	Deep	55.58	16.22	-	15.84	127.81	207.06	60.28	45.2	38.31	50.85	68.91	23.98
B2	Surface	97.63	17.35	-	18.2	68	50.88	51.6	52.06	24.54	48.65	25.78	32.85
	10 m	54.37	79.11	-	31.93	68.59	401.77	54.01	74.51	18.93	45.39	35.14	33.77
	Therm	36.82	32.36	-	-	50.82	215.07	88.58	72.7	13.77	52.61	29.03	32.7
	Deep	56.24	25.55	-	49.14	50.86	118.59	50.14	66.6	21.74	48.83	31.64	44.34
KK	Surface	16.77	81.15	-	26.6	43.33	205.52	73.93	9.87	40.41	33.97	30.35	28.64
	10 m	63.21	37.9	-	63.31	77.12	70.57	46.58	75.96	31.82	29.08	35.68	64.5
	Deep	39.46	32.7	-	29.03	74.11	85.64	51.6	77.6	43.52	33.23	32.72	28.48

Table 3. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
KK coast	Surface	58.26	254.67	-	37.13	105.68	221.73	68.95	66.32	25.67	35.7	55.31	81
	10 m	44.08	32.28	-	17.62	20.36	236.35	44.97	353.6	23.08	48.84	120.65	35.63
KK medium	Surface	43.95	149.75	-	17.02	46.82	247.77	37.98	1483.86	-	-	72.14	37.44
	10 m	120.08	49.17	-	26.7	27.01	356.61	56.69	1307.55	-	-	46.39	84.19
Adalar S.	Surface	135.72	71.97	-	97.42	73.19	320.94	304.69	8476	67.32	84.26	300.09	134.54
	Deep	76.93	105.91	-	195.31	-	-	146.29	82.24	145.52	-	-	-
Eyüp-Sütlüce	Surface	62.05	50.06	-	145.18	81.25	305.9	54.82	111.55	72.1	185.99	76.02	26.06
	Deep	42.22	56.81	-	128.15	59.82	179.04	47.99	99.34	50.68	113.88	56.79	211.42
Haliç Bridge	Surface	138.55	178.02	-	107.3	62.6	290.78	99.87	93.55	53.12	69.67	96.22	225.62
	Deep	80.45	65.79	-	84.15	61.46	231.72	75.77	79.18	43.31	76.55	77.88	77.1
V.Sultan Bridge	Surface	80.7	56.59	-	40.76	176.83	110.88	69.79	79.1	59.35	168.55	74.4	46.75
	Deep	54.59	368.15	-	35.83	83.34	215.7	47.27	61.78	50.7	248.23	64.7	43.37
Unkapanı Bridge	Surface	104.63	51.04	-	33.77	60.89	101.21	88.98	86.5	31.86	93.58	67.87	237.36
	10 m	87.94	52.9	-	51.39	38.78	55.31	82.35	70.93	21.12	67.57	43.76	209.14
	20 m	59.07	49.11	-	27.89	522.09	254.47	81.4	41.78	24.93	41.52	52.45	80.58
	Deep	88.09	47.95	-	44.51	36.9	92.63	89.62	64.51	24.16	52.22	51.11	94.5
Galata Bridge	Surface	66.92	28.32	-	37.91	105.3	104.53	199.95	169.78	61.62	32.38	77.35	42.64
	10 m	51.47	35.8	-	80.96	48.67	95.87	61.23	69.86	52.94	39.65	41.06	32.84
	20 m	50.51	31.8	-	61.4	237.82	71.23	119.9	67.08	50.11	37.04	29.87	62.71
	Deep	54.48	30.91	-	27.96	55.74	130.24	69.07	81.82	53.78	37.15	67.4	27.59
MY1	Surface	60.24	68.8	-	40.34	111.21	75.04	39.05	95.03	24.51	42.02	21.77	64.89
	10 m	74.78	62.91	-	40.34	792.01	126.14	49.58	59.66	27.64	63.12	39.54	22.15
	Term	74.88	31.2	-	59.04	65.81	202.28	48.91	73.8	29.39	51.83	23.48	88.73
	Deep	68.36	24.22	-	22.83	50.37	101.08	45.7	61.97	18.02	56.52	11.42	40.97

Table 3. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
MY2	Surface	67.04	27.76	-	27.54	347.86	846.03	82.97	79.96	16.82	35.8	23.94	44.69
	10 m	72.9	19.4	-	32.41	68.31	123.91	63.58	55.3	58.17	39.74	22.56	35.25
	Therm	76.84	32.8	-	32.87	67.02	94.32	57.69	62.06	17.62	42.52	25.48	24.68
	Deep	27.28	37.52	-	30.99	37.72	231.48	155.22	68.78	64.74	53.85	24.72	25.18
MK	Surface	39.34	18.21	-	31.83	95.57	108.85	56.03	73.44	17.87	63.22	18.87	49.83
	Deep	10.99	16.22	-	282.47	125.25	97.3	27.25	61.59	23.87	62.18	45.16	25.06
MKC	Surface	12.24	27.89	-	38.17	72.15	210.9	-	-	-	-	-	-
	10 m	12.43	49.08	-	38.08	52.42	257.42	-	-	-	-	-	-
	Deep	12.76	36.42	-	23.44	80.53	356.01	-	-	-	-	-	-
MKC-D	Surface	-	27.89	-	-	-	125.13	69.42	92.36	11.99	20.16	24.7	30.36
	10 m	-	49.08	-	-	-	85.33	49.61	67.91	20.2	17.87	79.34	33.02
	Therm	-	-	-	-	-	92.77	31.65	33.61	30.69	16.01	11.16	56.34
	Deep	-	36.42	-	-	-	-	64.23	64.07	24.11	16.23	63.73	20.95
MBC	Surface	86.93	35.74	-	16.33	135.6	77.88	38.09	36.65	17.23	11.35	22.71	41.08
	10 m	64.28	34.76	-	47.37	61.88	54.86	53.41	75.11	83.61	58.75	25.03	308.3
	Therm	77.2	35.45	-	36.68	372.2	75.68	752.62	43.64	82.36	20.34	20.34	18.88
	Deep	94.78	40.13	-	52.15	78.5	136.74	23.64	78.49	16.4	22.44	25.18	22.44

Table 3. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
M3	Surface	-	43.34	-	-	68.16	-	-	63.23	-	-	46.73	-
	10 m	-	45.1	-	-	39.59	-	-	61.81	-	-	60.02	-
	Therm	-	-	-	-	-	-	-	99.36	-	-	63.98	-
	Deep	-	56.57	-	-	51.23	-	-	58.49	-	-	44.14	-
M8	Surface	-	45.19	-	-	68.36	-	-	67.36	-	-	30.93	-
	10 m	-	61.45	-	-	68.24	-	-	58.11	-	-	19.69	-
	Therm	-	86.29	-	-	44.09	-	-	66.57	-	-	22.89	-
	Deep	-	44.89	-	-	83.47	-	-	71.33	-	-	67.06	-
M11	Surface	-	32.49	-	-	84.6	-	-	61.49	-	-	32.18	-
	10 m	-	33.84	-	-	55.85	-	-	25.37	-	-	27.2	-
	Therm	-	48.03	-	-	122.45	-	-	81.68	-	-	22.64	-
	Deep	-	37.38	-	-	69.37	-	-	69.81	-	-	29.92	-
M14	Surface	-	36.66	-	-	60.99	-	-	76.21	-	-	63.89	-
	10 m	-	74.48	-	-	107.31	-	-	64.24	-	-	67.83	-
	Therm	-	36.44	-	-	68.31	-	-	87.5	-	-	59.95	-
	Deep	-	26.19	-	-	57.97	-	-	50.76	-	-	79.3	-
M20	Surface	-	13.99	-	-	71.13	-	-	133.07	-	-	21.18	-
	10 m	-	24.03	-	-	48.68	-	-	73.7	-	-	24.61	-
	Therm	-	50.04	-	-	59.39	-	-	79.87	-	-	36.09	-
	Deep	-	80.6	-	-	97.52	-	-	72.07	-	-	31.59	-
M23	Surface	-	40.43	-	-	107.8	-	-	78.62	-	-	26.58	-
	10 m	-	75.2	-	-	75.62	-	-	84.57	-	-	29.34	-
	Therm	-	63.14	-	-	76.77	-	-	657.44	-	-	72.57	-
	Deep	-	42.73	-	-	76.77	-	-	78.59	-	-	34.56	-

Table 4. Oil pollution level in 2007 of Bosphorus, Golden Horn and Sea of Marmara (μg/L)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
K0	Surface	29.45	32.06	31.51	63.4	31.93	15.04	-	45.76	33.23	169.9	13.51	15.7
	10 m	32.39	17.11	75.64	45.69	38.53	6.47	-	44.99	23.2	17.45	12.71	14.4
	Therm	25.85	43.92	-	55.88	51.47	-	-	26.22	22.43	17.57	13.83	-
	Deep	22.46	29.12	32.26	81.21	37.55	15.81	-	37.02	25.24	21.31	13.83	17.01
K0(A)	Surface	17.2	51.84	329.86	67.64	31.11	33.79	-	31.03	23.61	16.73	14.88	23.07
	10 m	31.57	40.77	42.67	70.42	38.09	55.02	-	32.84	37.66	19.51	12.09	14.98
K0(B)	Surface	35.74	112.78	25.16	59.56	30.51	35.9	-	46.91	28.37	17.4	19.99	11.82
	10 m	17.27	40.56	44.37	77.46	39.76	19.87	-	33.62	17.89	18.44	16.84	11.62
B13	Surface	70.18	37.34	28.48	39.59	30.52	11.72	-	27.85	23.77	16.81	13.19	13.99
	10 m	15.84	38.2	36.36	32.65	30.15	6.47	-	190.04	28.04	19.24	14.7	21.7
	Therm	24.97	50.23	31.39	30.83	29.16	46.97	-	38.55	37.73	20.33	18.12	1243.61
	Deep	32.58	48.27	35.7	274.83	28.14	20.82	-	30.16	28.64	88.4	13.19	455.77
B7	Surface	27.61	32.91	76.6	36.45	26.38	33.56	-	128.16	15.42	16.01	22.08	41.91
	10 m	22.04	44.36	20.83	41.5	34.63	12.99	-	35.82	31.85	19.06	12.03	113
	Therm	22.02	25.1	105.69	70.22	43.62	19.52	-	36.64	18.27	15.56	12.4	14.56
	Deep	19.72	35.03	25.28	331.9	44.34	15.61	-	29.82	17.1	25.94	17.25	12.93
B2	Surface	19.61	46.52	41.11	24.98	30.85	16.57	-	-	41.33	19.19	13.48	571
	10 m	27.45	71.76	31.93	51.46	22.23	24.73	-	-	28.66	14.92	14.76	35.13
	Therm	39.21	880.34	25.22	33.17	32.53	24.34	-	-	26.77	13.8	13.97	31.25
	Deep	17.95	53.49	43.18	38.56	38.99	28.71	-	-	27.83	19.89	18.94	-

Table 4. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
KK	Surface	43.94	39.72	27.67	-	33.45	27.15	-	33.69	43.31	26.37	17.04	24.44
	10 m	36.93	33.21	32.01	-	39.32	8.4	-	33.39	27.12	17.45	14.66	20.51
	Deep	33.92	25.29	30.63	-	44.65	70.16	-	36.56	29.87	17.89	11.73	21.28
KK coast	Surface	54.67	23	60.43	57.77	23.54	24.43	-	46.53	18.89	13.71	15.25	14.65
	10 m	58.85	58.8	37.48	74.26	35.88	46.81	-	37.51	47.36	14.65	15.59	22.85
KK medium	Surface	45.86	52.99	40.52	81.74	41.54	47.99	-	18.5	53.67	15.58	19.31	18.99
	10 m	44.99	74.67	34.14	62.68	37.37	46.06	-	55.38	41.5	267.03	21.47	11.58
Adalar S.	Surface	86.14	117.62	20.57	107.52	210.36	85.68	-	38.92	84.56	113.25	147.62	33.13
	Deep	-	-	-	-	-	-	-	-	-	-	-	-
Eyüp-Sütlüce	Surface	63.04	96.6	54.55	73.3	70.71	213.29	-	53.61	63.41	85.06	31.91	20.82
	Deep	56.16	125.69	38.87	57.17	66.61	99.37	-	111.87	76.06	39.66	29.24	26.82
Haliç Bridge	Surface	59.2	62.41	36.46	118.19	66.54	42.87	-	25.5	39.57	134.26	30.46	19.17
	Deep	61.55	42.55	28.12	81.63	83.24	51.75	-	57.22	53.08	18.88	37.62	21.35
V. Sultan Bridge	Surface	124.35	47.82	65.5	130.56	37.92	40.45	-	101.03	38.45	20.41	31.18	30.18
	Deep	110.08	77.11	24.58	67.19	44.57	50.49	-	36.98	52.1	16.46	22.65	19.6
Unkapanı Bridge	Surface	23	50.85	20.6	52.73	32.03	37.81	-	48.59	29.94	23.79	17.88	23.44
	10 m	39.15	203.46	27.96	56.77	45.43	7.41	-	45.99	17.05	13.78	21.43	13.53
	20 m	26.25	155.9	50.42	48.67	164.42	42.8	-	48.19	32.7	15.73	16.09	18.87
	Deep	31.1	141.05	46.99	40.25	39.43	30.93	-	55.2	39.54	315.22	21.14	23.92
Galata Bridge	Surface	40.18	39.3	35.98	59.97	59.73	30.79	-	42.78	20.27	16.83	16.78	17.57
	10 m	57.8	26.14	17.05	47.35	110.93	27.57	-	54.03	22.96	13.43	11.79	15.25
	20 m	50.69	42.2	26.32	58.05	54.56	67.23	-	5.23	26.97	12.53	14.55	18.47
	Deep	63.5	46.76	25.86	37.78	30.55	34.08	-	44.73	30.78	36.24	21.8	22.44

Table 4. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
MY1	Surface	19.7	33.94	34.45	42.47	43.32	42.59	-	41.33	32.98	23.94	13.34	15.96
	10 m	20.24	55.16	22.86	32.6	65.44	36.01	-	33.47	-	17.38	18.33	-
	Therm	441.76	28.06	20.24	30.01	53.82	33.09	-	37.41	41.38	16.41	13.42	28.22
	Deep	13.42	46.38	23.03	36.96	35.41	99.27	-	35.43	47.82	25.67	20.1	19.37
MY2	Surface	50.56	73.89	45.66	32.43	32.79	30.68	-	30.4	96.01	19.81	19.11	19.76
	10 m	27.19	34.81	29.7	33.89	34.83	19.32	-	41.69	-	16.41	13.71	-
	Therm	106.7	37.58	28.75	45.14	42.88	34.23	-	32.47	21.64	18.05	585.07	12.67
	Deep	28.3	32.83	25.7	28.1	28.96	17.2	-	28.78	42.79	20.19	423.67	10.49
MK	Surface	23.7	37.1	37.16	43.03	62.64	13.32	-	36.66	27.29	14.61	14.18	28.48
	Deep	23.22	39.17	43.57	37.22	65.8	26.6	-	62.08	25.75	145.97	14.97	21.78
MKC-D	Surface	28.81	31.06	41.39	57.5	29.76	45.61	-	30.83	29.51	26.64	22.35	12.91
	10 m	710.89	174.26	21.6	36.5	40.1	31.99	-	32.86	27.52	21.34	18.71	143.03
	Therm	14.56	28.15	15.63	42.72	25.83	35.06	-	29.42	29.12	34.44	16.24	10.4
	Deep	18.83	29.97	21.48	45.06	31.9	81.05	-	53.79	25.19	22.53	13.75	15.92
MBC	Surface	14.98	41.43	29.47	41.77	60.3	23.34	-	41.7	22.22	26.43	42.12	14.92
	10 m	22.97	40.59	31.62	40.98	30.65	16.31	-	35.63	56.5	15.69	13.17	-
	Therm	15.47	38.18	24.13	57.19	24.21	15.34	-	31.23	36.98	19.38	105.21	16.23
	Deep	28.62	40.46	39.8	56.78	25.95	14.36	-	33.94	19.09	16.99	13.73	16.7

Table 4. continued

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
M3	Surface	-	40.82	-	-	29.23	-	-	35.22	-	-	15.79	-
	10 m	-	52.7	-	-	31.28	-	-	-	-	-	16.06	-
	Therm	-	87.68	-	-	30.83	-	-	33.95	-	-	19.57	-
	Deep	-	32.24	-	-	31.19	-	-	40.05	-	-	71.16	-
M8	Surface	-	47.11	-	-	36.16	-	-	51.07	-	-	25.27	-
	10 m	-	51.58	-	-	27.12	-	-	34.6	-	-	18.26	-
	Therm	-	34.57	-	-	36.39	-	-	30.73	-	-	15.07	-
	Deep	-	28.04	-	-	41.72	-	-	41.75	-	-	13.08	-
M11	Surface	-	29.9	-	-	41.98	-	-	-	-	-	36.74	-
	10 m	-	38.43	-	-	70.34	-	-	-	-	-	16.4	-
	Therm	-	36.93	-	-	53.86	-	-	-	-	-	17.74	-
	Deep	-	24.75	-	-	31.95	-	-	-	-	-	15.1	-
M14	Surface	-	36.57	-	-	27.36	-	-	-	-	-	15.29	-
	10 m	-	41.08	-	-	26.61	-	-	-	-	-	12.94	-
	Therm	-	35.22	-	-	18.11	-	-	-	-	-	14.77	-
	Deep	-	37.68	-	-	30.08	-	-	-	-	-	13.51	-
M20	Surface	-	83.27	-	-	39.64	-	-	-	-	-	-	-
	10 m	-	24.34	-	-	28.6	-	-	-	-	-	-	-
	Therm	-	28.88	-	-	28.96	-	-	-	-	-	-	-
	Deep	-	52.06	-	-	31.68	-	-	-	-	-	-	-
M23	Surface	-	23.87	-	-	36.53	-	-	42.54	-	-	12.09	-
	10 m	-	41.92	-	-	28.01	-	-	37.15	-	-	101.51	-
	Therm	-	68.99	-	-	43.22	-	-	23.72	-	-	16.27	-
	Deep	-	27.59	-	-	16.19	-	-	31.48	-	-	94.81	-

Table 5. Oil pollution level in Bosphorus and Sea of Marmara in June, Sep., Nov. 2005 and March 2006 (µg/L)

		5-Jun	5-Sep	5-Nov	6-Mar
K0	Surface	8.08	1.67	75.38	316.64
	10m	10.78	2.41	177.26	28.24
	Therm.	10.39	2.64	79.44	29.42
	Deep	17.62	2.82	36.48	58.03
B13	Surface	2.23	4.67	70.57	32.65
	10m	3.46	2.43	68.3	28.29
	Therm.	3.2	2.22	63.84	37.85
	Deep	5.81	5.7	86.34	59.57
B7	Surface	17.45	2.7	35.63	59.79
	10m	15.19	4.23	38.14	31.89
	Therm.	13.49	4.05	45.09	28.9
	Deep	36.15	4.96	83.72	67.31
B2	Surface	10.19	12.04	75.99	39.2
	10m	10.72	2.65	149.11	27
	Therm.	19.93	3	33.85	67.09
	Deep	19.4	3.81	83.25	24.23
MD 11A	Surface	3.8	2.54	158.46	49.67
MD 13A	Surface	5.99	3.04	163.84	52.28
MD 14	Surface	5.53	4.32	179.31	53.99
MD 56	Surface	3.73	4.77	92.01	59.24
MD 59	Surface	2.4	2.1	75.98	37.02
MD 63	Surface	4.21	14.3	140.31	62.59
MD 72	Surface	6.26	1.8	73.64	49.76
MD 73	Surface	3.08	1.75	125.77	48.46
MD 86	Surface	2.42	2.13	73.17	52.42
MD 87	Surface	3.44	3.18	206.63	46.2
MD 89	Surface	11.75	1.99	898.17	44.75
M 3	Surface	1.87	-	60.56	-
	10m	6.04	-	74.02	-
	Therm.	-	-	63.07	-
	Deep	4.13	-	64.05	-
M 8	Surface	8.74	-	67	-
	10m	5.97	-	126.74	-
	Therm.	12.38	-	69.9	-
	Deep	2.9	-	70.71	-
M 11	Surface	3.56	-	66.71	-
	10m	2.38	-	88.73	-
	Therm.	7.02	-	61.43	-
	Deep	3.56	-	77.85	-

Table 5. continued

		5-Jun	5-Sep	5-Nov	6-Mar
M 14	Surface	12.47	-	106.54	-
	10m	4.03	-	54.56	-
	Therm.	5.84	-	53.33	-
	Deep	3.68	-	27.53	-
M 20	Surface	41.52	-	45.75	-
	10m	21.68	-	64.72	-
	Therm.	18.67	-	53.65	-
	Deep	14.65	-	104.85	-
M 23	Surface	3.18	-	60.55	-
	10m	3.65	-	39.14	-
	Therm.	2.36	-	427.61	-
	Deep	8.59	-	42.27	-
MKC	Surface	6.86	2.84	71.08	25.59
	10 m	3.08	2.01	99.03	14.48
	Deep	7.76	2.79	89.6	46.91
MBC	Surface	2.69	3.24	684.27	39.09
	10m	2.3	1.97	82.46	31.54
	Therm.	2.85	36.84	62.27	25.25
	Deep	4.54	12.82	91.88	31.36
MK	Surface	12.61	17.18	1309.15	55.16
	Deep	8.94	15.09	112.79	31.77
MY 1	Surface	3.45	3.09	89.32	32.73
	10m	18.13	6.34	98.89	35.29
	Therm.	6.22	4.05	78.92	30.06
	Deep	2.09	4.53	88.03	48.61
MY 2	Surface	8.87	2.19	41.54	50.89
	10m	3.27	1.98	57.98	44.17
	Therm.	7.37	3.76	42.1	37.06
	Deep	2.05	3.25	54.19	87.01
DD 1	Surface	3.48	22.32	118.9	111.04
IZ 5C	Surface	2.51	2.22	111.04	34.94
IZ 8	Surface	11.41	1.99	1224.46	50.02
IZ 17	Surface	3.21	2.93	1371.54	37.53
IZ 25	Surface	6.39	42.84	507.33	71.75
IZ 30	Surface	57.05	2.42	488.89	58.89
SD 1	Surface	21.62	4.51	110.1	114.63
D1	Surface	-	-	243.42	45.17
D3	Surface	6.34	1.71	122.71	50.35
D5	Surface	2.13	60.51	75.35	60
D7	Surface	-	-	121.15	56.46

The highest oil pollution level found are (µg/l):

in 2004 Dec.

in Istanbul Strait	at B_2 surface water	1223,06
	at B_7 10 m depth	1512,73
	at Kızkulesi (KK) surface	1182.65
in Golden Horn	at Galata Bridge deep	300.90
in Sea of Marmara	at MY_2 deep	325.32
	at MK deep	374.45

in 2005

in Istanbul Strait	at K0 Oct. therm.	2281.13
	deep	3173.67
in Golden Horn	at Adalar S. (AS) surface Oct.	1671.57
	Nov.	1543.97
in Sea of Marmara	at MK surfaceNov.	1309.15
	at IZ_8 surface Nov.	1224.46
	at IZ_{17} surface Nov.	1371.54
	at MD_{87} surface Nov.	849.47

in 2006

in Istanbul Strait	at KK 10 m. Aug.	1307.55
	at K0 therm. Dec.	422.28
	at B_2 surface May.	401.77
in Golden Horn	at V. Sultan Bridge deep Feb.	368.15
in Sea of Marmara	at MY_2 surface Jun.	846.03
	at MY_1 10m Feb.	792.01
	at MBC therm. Jul.	752.62

in 2007

in Istanbul Strait	at B_{13} therm. Dec.	1243.61
	at B_2 therm. Feb.	880.34
	surface Dec.	571.00
in Golden Horn	at Galata Bridge deep Oct.	315.22
	at Unkapanı B. deep Oct.	315.44
in Sea of Marmara	at MY_2 therm. Nov.	585.17
	at MY_1 therm. Jan.	441.76

1. Oil contamination levels in sediments

Oil contamination levels in sediments are shown in Table 6 – 8.

Table 6. Oil pollution level for sediments of Bosphorus and Sea of Marmara in 2004 (μg/g)

	m	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
KO	72	38.28	50.63	57.51	69.70	73.85	-	116.40	243.50	45.58	64.76	115.82	158.52
M3	28	-	59.60	-	-	35.29	-	-	78.02	-	-	81.10	-
M8	65	-	54.37	-	-	44.99	-	-	105.4	-	-	106.90	-
M11	66	-	19.98	-	-	8.87	-	-	62.08	-	-	55.50	-
M14	84	-	24.73	-	-	22.4	-	-	86.40	-	-	64.10	-
M20	92	-	29.0	-	-	17.54	-	-	38.90	-	-	25.20	-
MY1	43	179.30	115.05	88.45	253.65	370.02	121.07	324.50	49.02	5.01	59.37	218.90	345.13
MY2	89	22.14	8.70	-	37.73	20.35	19.27	37.50	9.80	9.45	3.41	25.11	13.93
MBC	50	33.60	30.81	19.00	37.87	46.84	34.64	-	58.93	84.50	7.90	27.30	40.33
MKC	25	96.81	695.50	15.77	219.64	638.85	262.19	112.50	442.50	1238.40	113.50	866.00	1151.40
MK	8	535.06	625.93	715.06	826.33	697.29	732.82	589.00	1094.49	578.16	270.00	1089.95	930.01

Table 7. Oil pollution level for sediments of Bosphorus and Sea of Marmara in 2005 (μg/g)

	m	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
KO	72	491.73	39.77	159.32	127.00	65.75	151.38	690.95	196.30
M3	28	-	276.66	-	-	28.08	-	-	483.92
M8	65	-	441.19	-	-	35.04	-	-	635.48
M11	66	-	24.86	-	-	34.48	-	-	399.01
M14	84	-	64.66	-	-	20.75	-	-	248.12
M20	92	-	77.15	-	-	14.69	-	-	262.26
MY1	43	775.09	500.93	626.39	199.29	72.28	353.27	344.35	308.13
MY2	89	37.87	39.77	17.88	19.78	9.16	12.63	262.74	269.35
MBC	50	62.01	86.24	63.47	32.09	28.83	29.13	282.22	451.81
MKC	25	913.30	1315.31	675.68	147.33	107.09	165.25	673.35	378.86
MK	8	728.17	1392.30	2763.76	497.71	262.70	129.73	377.10	332.15

Table 8. Oil pollution level for sediments of Bosphorus and Sea of Marmara in 2006 (μg/g)

	m	Jan.	Feb.	Mar.	Apr.	May	Jun.
KO	72	99.87	71.40	227.50	152.60	258.02	209.77
M3	28	-	138.40	-	-	357.00	-
M8	65	-	364.30	-	-	109.50	-
M11	66	-	195.40			120.40	-
M14	84	-	445.10	-	-	127.00	-
M20	92	-	91.80	-		69.17	-
MY1	43	208.40	305.30	324.70	341.90	779.50	629.10
MY2	89	59.60	31.60	31.00	51.90	64.13	36.96
MBC	50	136.70	66.30	72.30	70.30	78.77	124.82
MKC	25	480.80	685.50	115.30	724.70	245.87	290.60

The highest oil contamination found in sediment samples are (μg/g):

in 2004

Istanbul Strait	at K0, Aug.	243.50
Sea of Marmara	at MKC, Sept.	1238.40
	Nov.	1151.40
	at MK, Aug.	1094.49
	Nov.	1089.95

in 2005

Istanbul Strait	at K0, Jul.	690.95
Sea of Marmara (North part)	at MK, Mar.	2763.76
	Nov.	1689.25
	Feb.	1392.30
	at M_{11}, Nov.	249.19
	at MKC, Feb.	1315.31
	Dec.	921.55
	Jan.	913.30
Sea of Marmara (Middle/South part)	at MD_1, Nov.	898.17
	at MK, Nov.	1309.15
	at Izmit Bay IZ_8	1224.46
	IZ_{17}	1371.54
Çanakkale Strait	at D1 surface, Nov.	243.42

in 2006

Istanbul Strait	at K0, May	258.02
Sea of Marmara (north part)	at MK, Jan.	1859.10
	May	1527.25

The highest oil level found by our laboratory in 2002 (μg/g)

Istanbul Strait	at K0, May	72.00
Sea of Marmara	at MBC, Nov.	59.80
Çanakkale	at Gelibolu, Apr.	53.50

The highest oil level found by our laboratory in 2003 (μg/g)

Istanbul Strait	at K0, June	255.20
Sea of Marmara	at MY2, June	451.00
Çanakkale Strait	at Gelibolu, May	11.70

When these results compared with the earlier results showed that the pollution level increased during the years.

Conclusion

- The concentrations of oil in examined area show a considerably high variation due to local conditions.
- In Istanbul Straits the oil amount in the water column is not uniform.
- When the oil pollution results between Istanbul Strait and Çanakkale Strait were compared Istanbul Strait was found more polluted.

- In the examined area an important problem is discharges of cities into sea with the physical sample treatment.
- It was observed the oil concentration rose during the years due to increasing vessel especially tanker traffic.
- The cause of high pollution levels is for Bosphorus heavy ship traffic, for Sea of Marmara illegal discharge of ballast water from tankers came to Izmit refinery and sewage of urban/industrial water and for Golden Horn heavy boats traffic.
- It was observed in some stations a relationship on pollution levels between sea water and sediment.

Finally according to FAO (1982), sea water containing hydrocarbon level less than 2,5 µg/L can be classified as unpolluted. For the sediment less than 10 µg/g oil concentration is accepted also unpolluted (Marchand et al. 1982). When compared the oil levels found in our work with these limit values, all investigated area are polluted/highly polluted.

Özet

Bu çalışmada Türk Boğazlar Sistemi'nde (İstanbul Boğazı, Marmara Denizi ve Çanakkale Boğazı) ve buna ek olarak Haliç'te 2004-2007 yılları arasında deniz suyunda ve sedimentte petrol kirliliği tayinine ait sonuçlar verilmiştir. Bu incelenen bölge örneklerinde deniz suyunda en yüksek kirlilik İstanbul Boğazı'nda 2004'te B7 istasyonunda 10 metre derinlikte 1512.73 µg/L, 2005'te K0 termoklinde 3173.67 µg/L, 2006'da KK'da 1307.55 µg/L, 2007'de B13 termoklinde 1243.61 µg/L olarak bulunmuştur. Sediment örneklerinde en yüksek kirlilik 2004'te Marmara Denizi'nde MKC'de 1238.40 µg/g, 2005'te MK'da 2763.76 µg/g ve 2006'da yine MK'da 1859.10 µg/g olarak bulunmuştur. Yüksek petrol kirliliğinin sebebi olarak İstanbul Boğazı için büyük sayıda gemi trafiği, Marmara Denizi için İzmit rafinerisine gelen tankerlerin kaçak balast sularını vermesi ve buna ek olarak bölgedeki yoğun endüstri ve şehir atık suları sebep görülmüştür. Diğer bir özellik de bazı istasyonlarda deniz suyu ve sedimentteki petrol kirliliği arasında bir bağıntı görülmüştür.

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