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VERTICAL DISTRIBUTION OF MERCURY IN THE SEA OF MARMARA

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SUMMARY: The concentration of total mercury (Hg_T), fluorescing material (FM), dissolved oxygen (DO), temperature (T), density (SIG-T) and salinity (S) was determined in the Sea of Marmara, Dardanelles and Bosphorus Straits. During the late winter and early spring time the vertical distribution of Hg_T and fluorescing material (FM) in the water column was similar.

KEYWORDS: total mercury (Hg_T), Sea of Marmara, fluorescing material (FM), salinity (S), temperature (T), dissolved oxygen (DO), density SIG-T).

INTRODUCTION

Mercury and its compounds are cumulative and toxic to living organisms at mg levels[1,2]. It can be transformed in the environment[1,3,4] by forming covalent bonds and it strongly coordinates with (-SH) ligands of biological molecules[1]. It forms complexes with Cl^-, Br^- and OH^- [5]. The humic matter, fulvic matter (common in natural waters), dissolved and particulate organic matters affect the distribution, speciation and bio-availability of the mercury[2,6,7]. Whilst it is well established that biogeochemical processes play an important role on the speciation, concentration and distribution of mercury in sea water[1,8,9] there, nevertheless, appears to have been no clear estimate of the first order processes dominating the environmental cycling and distribution of mercury.

Here, we report the vertical distribution of Hg_T as well as FM, S, T, SIG-T and DO at Bosphorus and Dardanelles straits and the Sea of Marmara.

MATERIAL AND METHODS

The sea water samples were collected during the cruises of R/V BILIM (METU Inst. Mar. Sci.) in the Sea of Marmara between 1987 and 1989. Sampling locations are shown in Fig. 1.

Mercury was measured by Cold vapor atomic absorption technique. After reduction with $NaBH_4$ gas phase was stripped with nitrogen and the reduced mercury was collected on a silver packed micro column[10,11,12]. FM was measured by using fluore spectrometer at an emission wave length of 455 nm, excitation wave length 360 nm slit width 60 nm against HM standard of land origin without any pre treatment or extraction. S, T, DO and SIG-T data was obtained by a Seabird Model 9 CTD probe.

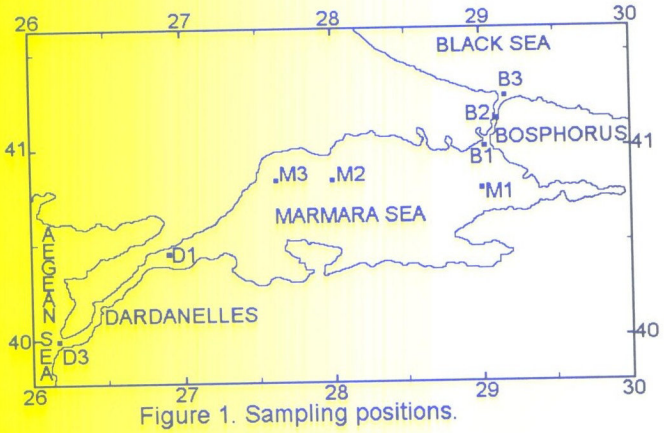

Figure 1. Sampling positions.

RESULTS AND DISCUSSIONS

The Sea of Marmara is a passage between Black Sea and Mediterranean Sea. It has three depressions about 1200 m deep located along the line extending from the Bosphorus to the Dardanelles. The hydrography of the system is dominated by the interaction of the saline Mediterranean waters flowing as an under current through the Dardanelles in to the Sea of Marmara and via Bosphorus to the Black Sea. Black Sea water flows through the Bosphorus to the Sea of Marmara and through Dardanelles to the Aegean Sea as a surface current[13,14]. This results in a stratified water column with a marked halocline separating a superficial layer of salinity 22-25°/oo from underlying saline (38.5°/oo) water. The thickness of the upper layer is about 20 m but, in the Bosphorus Strait it increases towards Black Sea and at the Bosphorus-Black Sea junction it is about 50 m. Strong stratification of the water masses coupled with the topographic restrictions imposed by two shallow sills of the Dardanelles and Bosphorus inhibits the efficient ventilation of deep waters. Oxygen is continually depleted by bacterial decomposition of the detritus formed by primary production. The primary productivity rate in the region is 68-171 gC/m^2-year [15]. The hydrographic characteristics of the Sea of Marmara and its straits have been discussed in detail by Miller[16], Unluata et al[13].

The concentration of Hg_T in the upper layer of the Sea of Marmara lies between 2.7-5.3 ng/L having a mean value of 3.8 ng/L. The average Hg_T concentration in the lower layer was 3.4 ng/L and the range was 2.0-4.4 ng/L. The results are summarized in Table 1 and some profiles are given in Figure 2. The mercury distribution in the Sea of Marmara is almost uniform in the lower layer below 300 m whereas in the upper layer, more or less, it varies with depth.

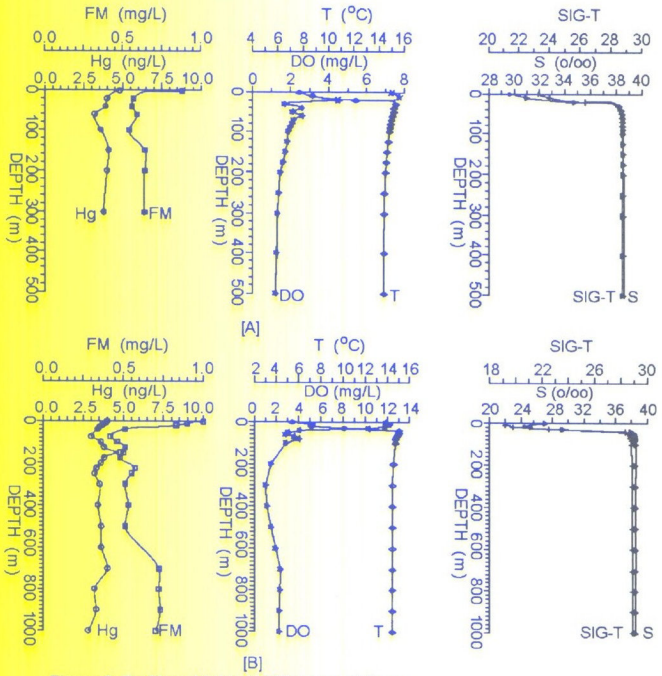

Figure 2. Profiles obtained at Marmara stations.
A-Sta.M1 (Feb.1987); B-Sta.M2 (March 1987).

Table 1. Mercury concentration in the Sea of Marmara

Depth	Mercury Concentration (ng/L). STATION M1				STATION M2				STATION: M3			
(m)	MAX	MIN	n	MEAN	MAX.	MIN.	n	MEAN	MAX	MIN	n	MEAN
0	5.3	2.7	8	3.5	5.0	3.3	5	4.0	4.2	3.2	6	3.8
10	4.3	3.3	6	3.8	5.4	4.1	4	4.6	4.1	3.5	3	3.8
20	3.9	3.4	7	3.6	4.3	3.2	5	3.7	4.5	2.0	6	3.4
30	4.0	3.4	5	3.7	3.5	3.3	3	3.5	3.2	2.8	2	3.0
40	4.0	3.6	5	3.8	4.0	3.5	2	3.8	3.4	2.9	2	3.2
50	3.5	2.6	8	3.1	4.1	2.6	4	3.4	4.2	3.5	5	3.8
75	4.3	3.0	5	3.7	3.7	2.5	4	3.2	3.8	2.4	5	3.0
100	3.5	2.2	8	3	3.8	2.5	5	3.7	3.8	3.0	5	3.5
125	3.3	2.7	3	2.9	3.5	3.0	2	3.3	3.8	2.5	2	3.3
150	4.4	2.0	8	3.4	3.6	2.5	3	3.0	3.7	2.1	4	3.2
175	4.3	3.4	3	3.8	3.5	3.0	2	3.3	3.8	2.3	3	3.0
200	4.3	2.6	7	3.4	4.3	2.4	4	3.3	3.3	3.3	1	3.3
250	3.6	3.2	6	3.4	4.0	3.0	4	3.4	3.8	3.0	3	3.3
300	4.0	3.2	7	3.5	4.4	2.8	4	3.3	4.2	3.0	3	3.4
800	3.9	3.1	4	3.6	4.4	2.8	4	3.3	3.2	3.2	1	3.2
1000	3.8	3.2	3	3.4	3.1	2.4	3	2.8	3.4	2.8	3	3.2

The Hg_T concentration in the Bosphorus is summarized in Table 2. The vertical distribution is given in Fig. 3. The average upper layer concentration along Bosphorus was 3.8 ng/L, ranging between 1.8-5.0 ng/L, in the lower layer 3.7 ng/L and the range was 2.3-5.0 ng/L.

The mercury concentration measured in the Dardanelles strait is given in Table 3 and the vertical distributions are given in Fig. 4. The average Hg_T concentration along this strait was 3.8 ng/L in the upper layer having a range of 3.0-4.8 ng/L. The average lower layer concentration was 4.2 ng/L ranging between 3.3-5.3 ng/L.

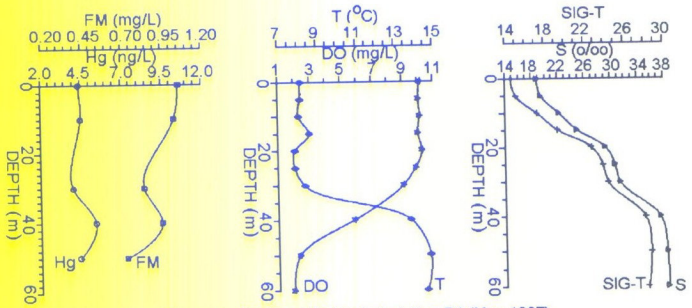

Figure 3. Profiles obtained at station B1 (May.1987)

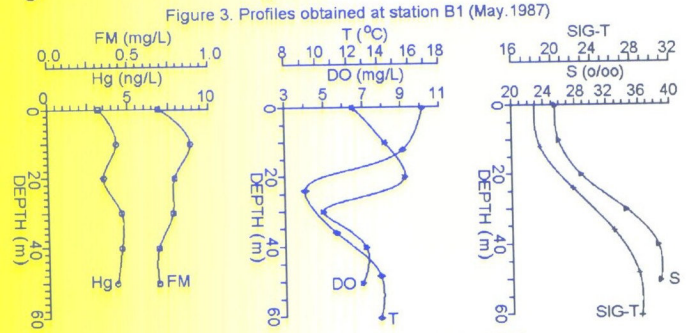

Figure 4. Profiles obtained at station D1 (May,1987)

Table 2 Mercury concentration along Bosphorus strait.

	Mercury Concentration (ng/L)											
Depth	STATION: B3				STATION: B2				STATION: B1			
(m)	MAX.	MIN.	n	MEAN	MAX.	MIN.	n	MEAN	MAX.	MIN.	n	MEAN
0	4.3	2.4	8	3.4	4.5	3.3	4	3.8	4.3	3.4	8	3.8
10	4.6	2.4	6	3.7	4.4	3.6	4	3.9	4.7	3.9	6	4.1
20	4.7	2.0	8	3.3	4.0	3.5	3	3.7	4.7	4.0	5	4.3
30	5.0	2.7	6	3.9	4.6	1.8	3	3.3	4.5	3.0	8	3.7
40	4.7	2.3	7	3.3	4.6	3.0	4	3.7	4.4	3.2	8	3.7
50	5.0	2.4	7	3.6	4.4	3.0	3	3.6	3.9	3.5	4	3.7

Table 3 Mercury concentration along Dardanelles strait.

Depth (m)	Mercury Concentration (ng/L). STATION: D3 MAX.	MIN.	n	MEAN	STATION: D1 MAX.	MIN.	n	MEAN
0	4.4	3.6	7	3.9	4.6	3.2	6	3.8
10	3.9	3.3	6	3.6	4.8	3.0	5	4.0
20	4.2	3.0	6	3.5	4.7	3.5	6	4.0
30	4.6	3.3	4	4.1	4.6	3.5	4	4.0
40	4.9	3.8	5	4.3	4.6	4.5	4	4.5
50	5.3	3.6	5	4.4	4.6	4.3	4	4.4
70	4.5	4.4	4	4.5	4.7	4.3	2	4.5

Generally in the late winter and early spring sampling periods the vertical distribution of the FM (fluorescing material) and mercury is in phase (Fig. 2, 3, 4). It is probable that a great portion of FM is consists of humic and fulvic type materials. It is known that HM can strongly and selectively bind mercury[6]. The approximate formation constant was calculated to be 1.75×10^5 for Humic material[17].

Total mercury (Hg_T) concentration in the Sea of Marmara are lower than those in the open Mediterranean Sea. Ferrara[18] reported 1.4-8.0 ng/L of mercury in the Tyrrhenian Sea an average of 6.3 ng/L. In the NE Mediterranean the proposed Hg_T concentration by Salihoglu[19] was 2.5-7.5 ng/L (excluding those values from river deltas) with an average of 4.1 ng/L. The primary production in the Sea of Marmara is much higher than that of the Mediterranean Sea. Mercury concentrations in plankton (phytoplankton and zooplankton) are enriched as compared to sea water by a factor of 1000 to 5000, showing that the enrichment from sea water to plankton is the highest among all trophic levels[1]. It is clear that plankton remove and concentrate mercury from the sea water very effectively, after their death they carry mercury down to the sediment by sinking. As a result, any mercury input is at least partially removed within a short time period. This could be the cause of the lower and relatively constant Hg_T concentration in the Sea of Marmara when compared to the Mediterranean Sea.

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