

## Survey of Heavy Metal Distribution in Greek Sediments

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Several oceanographic investigations have been carried out within the last 15 years in order to study heavy metal distribution in Greek surface sediments. Samples were collected from various polluted or partly polluted Greek areas, as well as from some unaffected regions. Collection of the samples was made using a 0.1m<sup>2</sup> van Veen grab. For the determination of the metals, 5g of the dry material was shaken with 2N HCl for 16 hours at room temperature. The leachates were processed on a Perkin-Elmer 305 B A.A.S. (SATSMADJIS, J. & VOITSINO-TALIADOURI, F. 1981). The study of each of the above mentioned areas lasted from one to five years.

Table I: Metal concentrations of Greek unpolluted regions.

	Fe (%-%)	Cr	Ni	Mn	Zn	Co	Cu	Pb	$\sigma$ of $\bar{q}$	$v$ of $\bar{q}$	$Q$	Ref.
	ppm											
Kavala	0.8-2.6	20-278	11- 47	65- 417	24-90	0-10	4-24	5-36				4
(mean)	1.4	105	22	273	67	5	16	30				
$\bar{q}$	0.82	1.03	0.24	0.45	1.37	0.42	0.89	1.50	0.45	54.07	0.84	
Thermaik.	1.2-2.2	66-120	55-105	215- 740	32-74	14-18	8-28	11-27				4
(mean)	1.8	75	81	465	48	17	18	17				
$\bar{q}$	1.06	0.93	0.67	0.76	0.98	1.33	0.94	0.90	0.17	17.37	0.97	7
Pagassit.	1.3-2.7	50-186	32-228	290-2790	38-72	8-22	9-25	19-30				7
(mean)	1.8	105	90	980	58	15	17	24				
$\bar{q}$	1.06	1.03	0.97	1.60	1.18	1.25	0.94	1.20	0.21	18.38	1.15	4
N.Euboek.	0.3-3.0	40-250	50-300	120-1000	9-46	3-30	-	-				4
(mean)	1.9	157	207	557	31	20	-	-				
$\bar{q}$	1.12	1.54	2.22	0.91	0.63	1.67	-	-	0.58	42.73	1.35	4
S.Euboek.	0.6-1.5	37- 97	25-144	165- 555	25-44	4-15	3-15	12-27				4
(mean)	2	75	90	370	7	9	20	19				
$\bar{q}$	0.71	0.65	0.82	0.60	0.73	0.83	0.50	1.00	0.15	21.20	0.73	4
Elefsis	0.8-1.1	50- 65	80- 95	280- 325	55-68	7-10	28-33	25-32				9
(mean)	1.0	60	90	320	60	8	30	30				
$\bar{q}$	0.98	0.99	0.97	0.52	1.22	0.67	1.67	1.50	0.45	46.71	0.96	5
Navarino	0.2-3.0	12-251	8-123	243- 600	7-81	4-15	0-32	2-28				5
(mean)	2.3	180	91	460	62	12	23	19				
$\bar{q}$	1.35	1.76	0.98	0.75	1.26	1.00	1.28	0.95	0.31	26.93	1.17	4
Patraik.	1.6-3.2	55-119	60-132	750-2610	43-88	11-23	16-43	11-20				4
(mean)	2.2	100	110	1420	72	19	35	16				
$\bar{q}$	1.65	0.98	1.18	2.32	1.87	1.98	1.94	0.80	0.50	33.63	1.49	4
Messolon.	1.0-2.8	56-112	40-112	470-1380	30-80	6-16	8-34	6-17				4
(mean)	1.9	73	80	764	60	11	23	12				
$\bar{q}$	1.12	0.72	0.86	1.25	1.22	0.92	1.28	0.60	0.26	25.95	1.00	6
Amvrakik.	0.5-3.0	27-177	33-188	323-3820	12-80	4-30	2-31	7-21				6
(mean)	2.2	125	131	870	62	18	24	12				
$\bar{q}$	1.29	1.22	1.41	1.42	1.26	1.50	1.33	0.60	0.28	22.32	1.25	4
Lesbos	0.3-2.1	40-247	20-315	172-1126	18-43	0-19	3-12	10-39				4
(mean)	1.2	155	89	447	52	9	8	28				
$\bar{q}$	0.71	1.32	0.96	0.73	0.65	0.79	0.44	1.40	0.38	42.22	0.89	8
Milos	0.3-0.6	10-19	6- 21	113- 251	15-18	2- 4	2- 4	2- 7				8
(mean)	0.4	14	12	170	17	3	3	5				
$\bar{q}$	0.23	0.14	0.13	0.28	0.35	0.25	0.17	0.25	0.07	33.26	0.22	4
East Aege.	1.4-3.3	52-157	39-291	280-2640	25-55	8-24	4-29	11-22				4
(mean)	2.2	84	84	84	38	15	17	17				
$\bar{q}$	1.29	0.84	1.41	1.41	0.77	1.25	0.94	0.85	0.27	24.77	1.09	

Analysis of the data indicates that polluted subregions can be identified in some of the studied areas. In Kavala Bay, the oil-platforms and the fertilizer factory raise the amounts of Pb (322-908ppm), Zn (110-510ppm) and Cu (45-226ppm), while in Thermaikos Gulf, the industrial effluents, as well as, the domestic wastes raise more or less the concentrations of all metals Fe (2.2-5.3%), Cr (140-390ppm), Ni (105-270ppm), Mn (275-1340ppm), Zn (74-2600ppm), Co (19-37ppm), Cu (28-200ppm) and Pb (28-330ppm). The industries and the city of Volos cause a slight enrichment of the values of Cr (66-70ppm), Ni (46-53ppm), Zn (72-94ppm), Cu (27-39ppm) and Pb (30-53ppm) in surface sediments of Pagassitikos Gulf. In the adjacent N. Euboikos Gulf, a Fe-Ni alloy smelting plant causes heavily enriched values of Fe (3.0-25.4%), Cr (250-1200ppm), Ni (300-3550ppm), Mn (1140-4560ppm), Zn (46-320ppm) and Co (30-212ppm). Surface sediments in Elefsis Bay, show heavy metal pollution [Cr (70-390ppm), Zn (100-1680ppm), Cu (20-230ppm), Pb (40-400ppm) and Cd (0.2-2.5ppm)] due to the influence of industrial effluents and domestic wastes from three and a half million people of the greater Athens area. Finally, in Navarino Bay, a tanker shipwreck caused an enhanced Pb-value (53ppm). Our values are comparable with those reported by other investigators (VARNAVAS *et al.*, 1984, ANGELIDIS *et al.*, 1984, etc). However, a close comparison is not attempted herein because of the different extraction methods used.

Table I shows metal concentrations of unaffected sections from the polluted regions, as well as metal concentrations from other unpolluted Greek areas. Comparison of metal concentrations in the various unpolluted areas may be made with the use of an enrichment ratio  $\bar{q}$  = mean concentration of a metal for each area/mean concentration of a metal for all areas. From Table I is evident that the coefficient of variation of  $\bar{q}$  does not vary considerably between regions (17.37-54.07). Factor  $Q$  (the mean value of all  $\bar{q}$  ratios for each area) gives an idea about the concentration level of the metals in each area comparing with the mean values of all unpolluted Greek regions. In the classification that follows regions characterized with coeff. of variation > 50.00 (arbitrary selected) are excluded. Hence, the unpolluted areas (according to their metal concentrations) may be arranged as follows: Patraikos Gulf ( $Q=1.49$ ); N.Euboikos G. ( $Q=1.35$ ); Amvrakikos G. ( $Q=1.25$ ); Navarino B. ( $Q=1.17$ ); Pagassitikos G. ( $Q=1.15$ ); East Aegean Sea ( $Q=1.09$ ); Messolonghi L. ( $Q=1.00$ ); Thermaikos G. ( $Q=0.97$ ); Elefsis B. ( $Q=0.96$ ); Lesbos Isl. ( $Q=0.89$ ); S.Euboikos G. ( $Q=0.73$ ); Milos Isl. ( $Q=0.22$ ).

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