Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 8 (16): 2919-2923, 2008
ISSN 1812-5654

Heavy Metals Distribution in Sediments from Dardanelles

[1]Rüştü Ilgar and [2]Erol Sari
[1]Department of Geography, Campus of Anafartalar,
Çanakkale Eighteen Mart University, 17100 Çanakkale, Turkey
[2]Institute of Marine Science and Management, Istanbul University,
Müşküle Sok. Vefa, 34470 İstanbul, Turkey

Abstract: The Çanakkale strait (Dardanelles), located between Marmara Sea and Aegean Sea. The concentrations of heavy metals in the twenty-two surface sediment samples from the Dardanelles and Creeks were determined. Total metal concentration in the bulk sediment varies in the range of Al 3.2-5.2%, Cu 6-50 ppm, Fe 1-3.4%, Mn 153-1960 ppm, Ni 6-75 ppm, Pb 7-328 ppm, Zn 21-2211 ppm. Al, Cu, Fe and Ni values are low compared to those from the shale averages values of these metals. The relatively high Mn, Pb and Zn values are derived from the rock formations and mineralized zones by the Umurbey, Musaköy and Sarıçay Creeks. Pb and Zn pollution in the Sarıçay Creek sediment is also originated from Industrial and domestic waste discharges of the Çanakkale City which its population is 54000.

Key words: Heavy metals, sediment, environment, dardannelles

INTRODUCTION

The strait of Çanakkale (Dardanelles) is a 62 km long water passage connecting the Aegean Sea and Marmara Sea (Fig. 1). Its width varies from 1.3 to 7 km with sill depth of -65 m. It has two-layer flow system, with the upper layer Black Sea waters and the lower layer Mediterranean waters flowing in opposite direction. The surface and subsurface current have velocities 50, 300 and 20, 50 cm sec^{-1}, respectively (Defant, 1961; Özsoy *et al*., 1986). The main source of fresh water and sediments to the Dardanelles is the Karamenderes sream in the Anatolian part. This stream have average suspended sediment discharges of 0.89 10^6 t $year^{-1}$ (EIE, 1993). There are a lot of minor creek flowing into the Strait of Çanakkale from Thrace (namely Münipbey, Sütlüce, Cumali, Ilgar, Kayaaltı, Bigalı and Eceabat) and Anatolian side (Lapseki, Umurbey, Yapıldak, Musaköy, Kepez and Sarıçay).

These creeks are and sediment samples point short in length with small drainage areas (Fig. 1). There are a few scale industries in the area surrounding the Dardanelles and small settlements such as Gelibolu, Lapseki and Eceabat. Their population is 18000, 6000 and 4000, respectively.

The study area is affected by two tectonically active regimes; the active tensional regime in Aegean Sea (McKenzie, 1978; Le Pichon and Angelier, 1981; Seyitoglu and Scott, 1991; Armijo *et al*., 1996) and

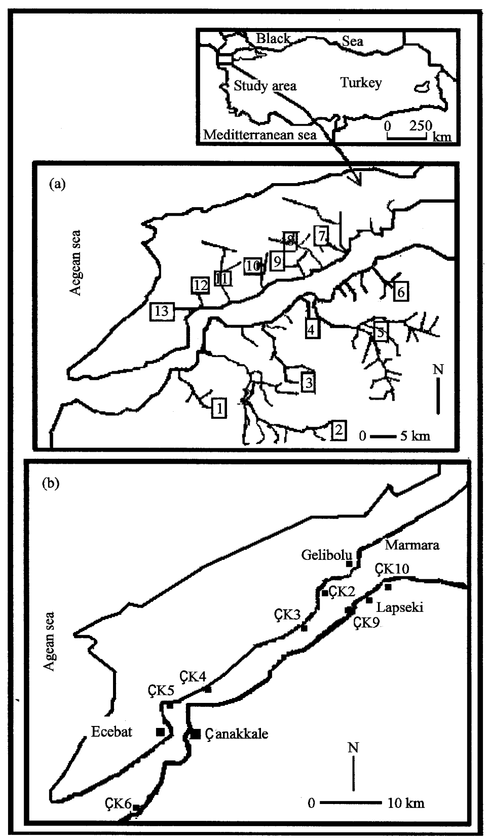

Fig. 1: (a-b) Map of the dardanelles region showing, its drainage area and sample locations

Corresponding Author: Rüştü Ilgar, Department of Geography, Campus of Anafartalar, Çanakkale Eighteen Mart University, 17100 Çanakkale, Turkey Tel: +90 5525928834 Fax: +90 2862120751

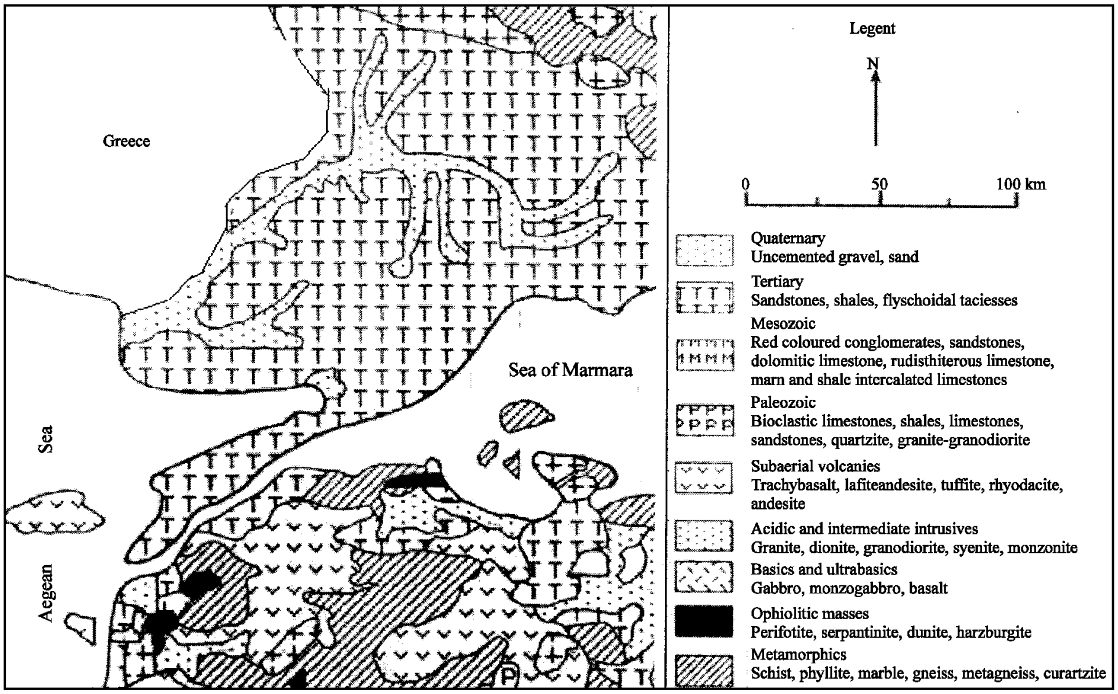

Fig. 2: Simplified geological map of Marmara surroundings (MTA, 1989; Ergin *et al*., 1999)

Miocene-Pliocene strike-slip faulting, escape tectonics and regional uplift activities along the western part of the Anatolian Fault Zone (Görür *et al*., 1997; Yaltırak *et al*., 2000). A geological map of the study area is shown in (Fig. 2). This Fig. 2 indicated that the northern and southern part of the Çanakkale Strait display different geological features. The Anatolian region is mainly built up of various Magmatic (Alkaline and calc-alkaline volcanic rocks) and metamorphic rocks. In Thrace region is mainly dominated with Tertiary-aged sedimentary formations.

The purpose of this study is to investigate the distribution and possible sources of metals in the surface sediment of the Dardanelles. For these study 22 surface sediment sample were collected and analyzed their Al, Cu, Fe; Mn, Ni, Pb and Zn contents.

MATERIALS AND METHODS

Twenty-two sediments samples were collected in the Dardanelles and several small creeks mouth during the 1996 cruises of R/V Arar (Fig. 1). The top of the 1 cm of the sediment was taken and kept in a refrigerator (~2°C) before drying and grinding.

In the laboratory, Sediment samples were dried at 105°C and ground in a mortar. Al, Cr, Cu, Fe, Mn, Ni, Pb and Zn contents were determined by Atomic Absorption spectrophotometer (AAS) after a total digestion. Involving HNO_3 + $HClO_4$ +HF acid mixture. The accuracy of the heavy metal analyses was checked with international standard samples (Table 1). The analytical precision was better than 10 at 95% significance level.

Table 1: Accuracy of ASS analyses used in this study

Reference material	Element	Measure value (This study) (ppm)	Certified value or range (ppm)
IAEA 405	Al	82400	72700-83100
IAEA 405	Cr	75	80-88
IAEA 405	Cu	44	46.5-48.9
IAEA 405	Fe	32970	36700-38100
IAEA 405	Mn	486.5	484-506
IAEA 405	Ni	29.3	31.1-33.9
IAEA 405	Pb	69.3	72.6-77
IAEA 405	Zn	252	272-286

RESULTS AND DISCUSSION

Distribution of heavy metal in the surface sediments: The general geochemical behavior of heavy metal which is known to accumulate in fine-grained sediments (Förstner and Wittmann, 1979; Farrah *et al*., 1980; Solomons and Forstner, 1984; Emelyanov and Shimkus, 1986; Horrowitz, 1991). There is generally a marked inverse correlation between grain size and metal concentration in the sediment. Çanakkale Strait is a narrow channel where current velocities are very high (Defant, 1961; Özsoy *et al*., 1986; Oguz and Sur, 1989; Alpar, 2000). As a result large abundance of sand and gravel fraction of sediment of terrigenous origin have been accumulated and the prevailing current patterns for fine-grained materials seem to be erosional rather than depositional (Bayhan *et al*., 2001). The bottom of the Çanakkale strait is covered largely by terrigenous sand and gravel (Bayhan *et al*., 2001). In this case, the metal values in the Çanakkale Strait sediments may be low values. In this study all the metal values in strait sediments are lower when comparing sedimentary rocks of these metal values (Table 2, 3). The distribution of Al (3.2-5.2%), Cu (6-50 ppm), Fe (1-3.4%) and Ni (6-50 ppm) contents in the Dardannelles creeks samples mostly resembles that of the shale averages values of these metals (Table 2, 3). Therefore, the geological weathering on land appears to be principal source of these metals in the samples.

Manganese contents amount to between 110 to 1960 ppm with a mean value of 545 ppm Mn (Table 2). Comparison with average shale value of 850 ppm (Krauskopf, 1985) reflects the presence of Mn in the studies samples largely at natural levels. The high (>850 ppm) Mn values are found at two stations, which is located at Musakoy (1945 ppm) and Umurbey (1960 ppm) creeks. This can be readily explained as the result of influx of material from mining activity. The other Mn values in the sediments mostly resemble that of average sedimentary rocks. The Pb contents of the Dardanelles and creeks sediments are lower than the average shale concentrations of 20 ppm Pb (Krauskopf, 1985), except for Umurbey Pb values (324 ppm). The total Zn concentrations range between 21 and 2211 ppm. The highest Zn values (>the shale average value of 90 ppm), 172 and 2211 ppm occurring at station Sarıçay and Umurbey creeks sediments. The inter element relationships among the studied heavy metals are given in Table 4.

The data show that; Zn content has positive covariance with Pb (r = 0.99), Mn (r = 0.65) and Cu (r = 0.54) contents of the sediments. Pb values display good correlation with Mn (r = 0.63) values. This is interpreted to be the result of common similar sources. The former is related to the presence of particular geological sources. The main natural sources for these elements are the Pb-Zn and Mn mining activity in the drainage area of creeks (Umurbey, sarıçay and Musaköy). The highest Mn, Zn and Pb concentrations are found in the Umurbey creek sediment, southern part of the Çanakkale Strait (Table 2). This indicates that the major supply of those elements to the Çanakkale Strait is the inputs by the Umurbey creeck. Mean Pb-Zn and Mn concentration in the Umurbey creek are higher than those of the other rivers and world average shown in Table 3 although these rivers drain watersheds that are much more industrialized than the Umurbey creeck drainage area. Only Lot (Temple) River sediment shows higher Zn concentrations than Umurbey Creek sediment.

Table 2: Heavy metal concentrations of bulk surface sediments in the Çanakkale Marine Strait, River and Creeks

Station name	Al (%)	Cu (ppm)	Fe (%)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)
River and creeks sediments							
Kepez	3.3	18	1.5	448	75	10	25
Sarıçay	5.0	50	2.6	325	17	61	172
Musaköy	3.8	10	1.5	1946	9	17	55
Yapıldak	3.3	20	1.6	323	21	20	49
Umurbey	3.2	40	1.2	1960	6	328	2211
Lapseki	4.4	7	1.0	110	12	18	29
Münipbey	4.6	12	1.7	714	43	8	32
Sütlüce	3.4	12	2.0	437	23	17	46
Cumali	4.1	7	1.2	389	27	6	21
Ilgar	3.3	11	1.7	546	45	8	37
Kayaaltı	5.2	19	2.7	608	73	11	57
Bigalı	4.1	19	2.6	788	68	7	57
Eceabat	4.0	6	1.2	153	23	7	30
Marine sediments							
ÇK 2	4.3	22	3.4	396	55	20	63
ÇK 3	3.6	12	1.9	379	43	12	42
ÇK 3-sub	4.7	20	2.7	373	42	14	57
ÇK 4	3.5	9	1.4	356	30	14	35
ÇK 5	3.9	9	1.5	392	31	14	35
ÇK 6	3.3	10	1.6	157	25	17	39
ÇK 9	4.5	22	2.3	348	41	14	76
ÇK 9 sub	4.5	20	2.5	317	40	17	54
ÇK 10	4.8	14	2.0	522	51	8	46

Table 3: Comparison study of heavy metal concentration in sediments of the Çanakkale strait and creecks with other river systems in the world

Sediment study	Al (%)	Cu (ppm)	Fe (%)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)
Present study	4.0	17	1.9	545	36	29.0	148
Umurbey Creek (in this study)	3.2	40	1.2	1960	6	328.0	2211
Erdek Bay (Balkıs and Çağatay, 2001)	7.2	28	3.0	384	52	40.0	125
Saros Gulf (Sarı and Çağatay, 2001)	NA	19	2.8	451	60	22.0	73
Sea of Marmara (Bodur and Ergin, 1994)	NA	33	3.3	1178	94	47.0	91
Shale (Krauskopf, 1985)	9.2	50	4.7	850	80	20.0	90
Danube River (Woitke *et al*., 2003)	3.3	66	3.0	819	50	46.3	187
Guadaira River (Gonzalez *et al*., 2000)	9.1	25	2.5	477	37	20.0	51
Lot River (Aundry *et al*., 2004)	NA	43	NA	NA	NA	140.0	2260
Garonne River (Audry *et al*., 2004)	NA	78	NA	NA	NA	84.0	643
Oude Delft (Qu and Kelderman, 2001)	NA	120	2.5	1710	na	246.0	541
Ganges River (Singh *et al*., 2003)	NA	55	4.0	1765	47	22.0	105
World average (Martin and Meybeck, 1979)	-	100	4.8	1050	90	-	350

NA: Not Analyzed

Table 4: Correlation coefficient of matrix geochemical parameters for 22 sediment samples

Parameters	Mn	Fe	Ni	Cu	Zn	Pb	Al
Mn	1						
Fe	-0.15	1					
Ni	-0.24	0.53	1				
Cu	0.26	0.42	-0.07	1			
Zn	0.65	-0.21	-0.35	0.54	1		
Pb	0.63	-0.20	-0.40	0.60	0.99	1	
Al	-0.20	0.54	0.28	0.23	-0.27	-0.25	1

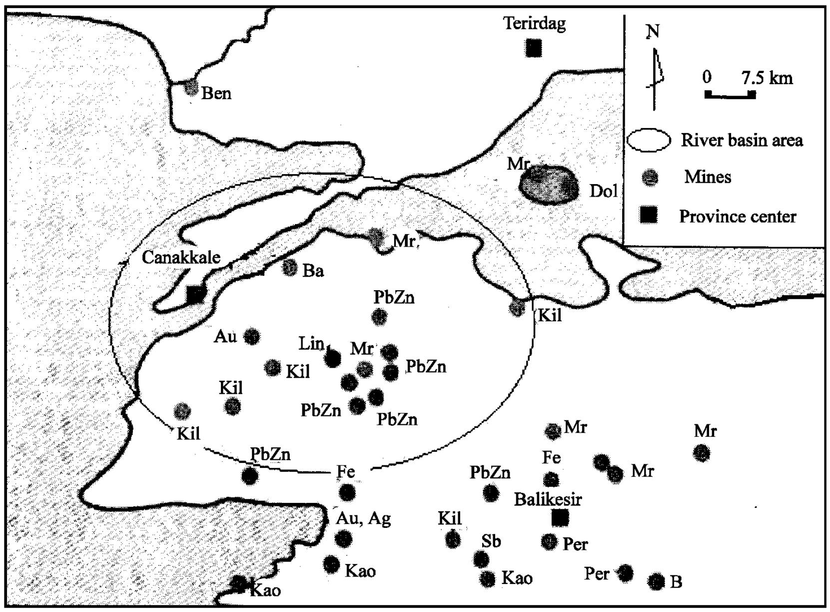

Fig. 3: Simplified mines map of the study area (http://www.mta.gov.tr)

CONCLUSION

Results from the heavy metal analyses obtained in this study indicated that the concentrations of Al, Cu, Fe and Ni are lower than the shale averages of these metals. A great part of the heavy metal (Mn, Pb and Zn) pollution must be derived from land based natural input and also all the results of heavy metals effected of coastline hinterland. With lesser anthropogenic contribution and carried into the Dardanelles by the Umurbey, Musaköy and Sarıçay Creeks. The main source of high heavy metals (Mn, Pb and Zn) is the erosion products of mineralised zones (Fig. 3) in the drainage basins of creeks. The source for anthropogenic inputs into the Dardanelles is mainly derived from Sarıçay Creek containing wastes of domestic and industrial activities of Çanakkale City.

REFERENCES

Alpar, B., 2000. Geophysical studies in the Marmara sea; their contribution to the regional geology. Turk. J. Mar. Sci., 6: 105-125.

Armijo, R., B. Meyer, G.C.P. King, A. Rigo and D. Papanastassiou, 1996. Quaternary evolution of the Corinth rift and its implications for the late Cenozoic evolution of the Aegean. Geophys. Res. Int., 128: 11-53.

Aundry, S., J. Schafer, G. Blanc, C. Bossy and G. Lavaux, 2004. Anthropogenic components of heavy metal (Cd, Zn, Cu, Pb) budgets in the lot-garonne fluvial system (France). Applied Geochem., 19: 769-786.

Balkis, N. and M.N. Çagatay, 2001. Factors controlling metal distributions in the surface sediments of the erdek bay, sea of Marmara, Turkey. Environ. Int., 27: 1-13.

Bayhan, E., M. Ergin, A. Temel and S. Keskin, 2001. Sedimentology and mineralogy of surficial bottom deposits from the Aegean-Çanakkale-Mmarmara transition (Eastern Mediterranean): Effects of marine and terrestrial factors. Mar. Geol., 175: 297-315.

Bodur, M.N. and M. Ergin, 1994. Geochemical characteristics of the recent sediments from the sea of Marmara. Chem. Geol., 114: 1-29.

Defant, A., 1961. Physical Oceanography. Vol. 1, Pergamon, Oxford, pp: 729.

EIE, 1993. Sediment data and sediment transport amount for surface waters in Turkey. pp: 41-42.

Emelyanov, E.V. and K.M. Shimkus, 1986. Geochemistry and Sedimentology of the Mediterranean Sea. 1st Edn. Reidel, Dordrecht, pp: 553.

Ergin, M., S. Kapur, Z. Karakas, E. Akça, Ö. Kangal and S. Keskin, 1999. Grain size and clay mineralogy of late quaternary sediments on a tectonically active shelf, the Southern sea of Marmara: Clues to hyrographic, tectonic and climatic evolution. Geol. J., 34: 199-210.

Farrah, H.D. and W.F. Pickering, 1980. The affinity of metal ions for clay surfaces. Chem. Geol., 28: 55-68.

Förstner, U. and G.T.W. Wittmann, 1979. Metal Pollution in the Aquatic Environment. 1st Edn. Springer, Heidelberg, Germany, pp: 486.

Gonzales, A.E., M.T. Rodriguez, J.C.J. Sanchez, A.J.F. Espinosa and F.J.B. De La Rosa, 2000. Assessment of metals in sediments in a tributary of guadalquivir river (Spain), heavy metal partitioning and relation between the water and the sediment system. Water Air Soil Pollut., 121: 11-29.

Görür, N., M.N. Çagatay, M. Sakinç, M. Sümengen, K. Sürk, C. Yaltirak and A. Tchapalyga, 1997. Origin of the sea of Marmara as deduced from neogene to quaternary Paleogeo-graphic evolution of its Frame. Int. Geol. Rev., 39: 342-352.

Horrowitz, A.J., 1991. A Primer On Sediment-Trace Element Chemistry. 1st Edn. Lewis Publishers, USA., pp: 135.

Krauskopf, K.B., 1985. Introduction to Geochemistry. International Series in the Earth and Planetary Sciences. 1st Edn. McGraw-Hill, Tokyo, pp: 617.

Le Pichon, X. and J. Angelier, 1981. The Aegean Sea. Phil. Trans. R. Soc. London, A, 300: 357-372.

Martin, J.M. and M. Meybeck, 1979. Elemental mass balance of materials carried by major world rivers. Mar. Chem., 7: 173-206.

McKenzie, D.P., 1978. Active Tectonics of the Alpin-Himalayan Belt: The Aegean Sea an Surrounding Regions. Geophys. J. R. Astr. Soc., 55: 217-254.

MTA, 1989. Geological Map of Turkey, 1:2,000, 000, MTA, Ankara, Turkey.

Oguz, T. and H.I. Sur, 1989. A two-layer model of water exchange through the dardanelles strait. Oceangr. Acta, 12: 23-31.

Özsoy, E.O.T., L. Ma and Ü. Ünlüata, 1986. Oceanography of the Turkish Straits: 1st Annual Report, Vol. I. Erdemli Institute of Marine Sciences, IÇEL Turkey, pp: 269.

Qu, W. and P. Kelderman, 2001. Heavy metal contents in the delft canal sediments and suspended solids of the river rhine: Multivariate analysis for source tracing. Chemosphere, 45: 919-925.

Sari, E. and N. Çagatay, 2001. Distributions of heavy metals in the surface sediments of the gulf of saros, NE aegean sea. Environ. Int., 26: 169-173.

Seyitoglu, G. and B. Scott, 1991. Late cenozoic crustal extension and basin formation in West Turkey. Geol. Mag., 128: 155-166.

Solomons, W. and U. Forstner, 1984. Metals in Hydrocycle. 1st Edn. Springer, Heidelberg, Germany.

Singh, M., G. Müller and I.B. Singh, 2003. Geogenic distribution and baseline concentration of heavy metals in sediments of the Ganges River, India. J. Geochem. Exploration, 80: 1-17.

Woitke, P., J. Wellmitz, D. Helm, P. Kube, P. Lepom and P. Litheraty, 2003. Analysis and assessment of heavy metal pollution in suspended solids and sediments of the river danube. Chemosphere, 51: 633-642.

Yaltirak, C., B. Alpar, M. Sakinç and H. Yüce, 2000. Origin of the strait of Çanakkale (Dardanelles): Regional tectonics and the Mediterranean Marmara incursion. Mar. Geol., 164: 139-156.