Bull. Environ. Contam. Toxicol. (1994) 52:382–387

Environmental Contamination and Toxicology

Metals in Sediments of San Andres Lagoon, Tamaulipas, Mexico

F. G. Vazquez,[1] L. G. Aguilera,[1] V. K. Sharma[2]

[1]Instituto de Ciencias del Mar y Limnologia, UNAM, Cd. Universitaria, D.F., A.P. 70-305, C.P. 04510, Mexico
[2]Center for Coastal Studies, Texas A&M University, Corpus Christi, 6300 Ocean Drive, Corpus Christi, Texas 78412, USA

Received: 29 March 1993/Accepted: 20 July 1993

Heavy metal pollution in water is generally associated with industrial and municipal discharges into rivers, estuaries and lagoons (Brooks 1989; Clark 1986). Once metals are in the water column, they may be taken up by organisms, deposited in the sediments or remain for some period in the water itself (Berner and Berner 1987; Forstner and Wittman 1981). The deposition rate in sediments depends on, among other factors, metal concentration in surface sediments. The concentrations of heavy metals in sediments of coastal, estuarine and lagoon environments have been determined by many workers (Bruland et al. 1974; Goldberg et al. 1978; Paez et al. 1986).

For the past several years, we have been interested in determining trace and heavy metal concentrations in the lagoons in Mexico to establish the levels of metal pollution (Vazquez et al. 1990, 1991, 1993 a,b). The work reported here is the completion of our ongoing study in San Andres lagoon. San Andres lagoon is located north of two industrial ports, Tampico and Altamira. In this industrial zone, the basins of the Panuco and Tamesi Rivers are localized and have industrial effluent throughout the year. All these activities and the input of the Tigre River, which runs through an agricultural and cattle-raising region, may affect the biogeochemistry of the San Andres lagoon. In the present work, we report concentrations of Cd, Co, Cu, Fe, Mn, Ni, Zn and Pb in sediments of San Andres lagoon. The measurements were made in different seasons; Rain-84 (August-September 1984); North (October-December 1984); Dry (April 1985); and Rain-85 (April-June 1985).

MATERIALS AND METHODS

The sediment samples were collected with a Van Veen grab

Correspondence to: F. G. Vazquez

from the central area of San Andres lagoon (oyster banks) at eleven stations (Fig 1) during a period from August 1984 to June 1985. All stations were sampled in every season and one sample was collected at each station during each sampling event. The samples were carefully taken from the surface to 4 cm in the central portion of the grab to avoid contamination. The samples were taken with an acid - washed plastic spatula ($HCl:HNO_3$; 1:5), placed in plastic bags and stored frozen. One to two grams of 1-2 cm stratum were analyzed.

Metal concentrations were analyzed by the method of Bruland et al. 1974. Sediment samples were digested successively with HCl, HNO_3, $HClO_4$, HF and heated to total dissolution. The samples were analyzed with a Perkin Elmer 2380 atomic absorption spectrophotometer equipped with HGA-400 graphite furnace. Copper, Fe, Mn, Pb and Zn were analyzed by flame AAS and Cadmium, Co, and Ni were analyzed by graphite furnace. A certified reference material (International Laboratory of Marine Radioactivity, Mosee Oceanographiqul, MC 98000, Monaco) was regularly submitted to the same digestion procedure and analyzed for metals. Measured metal concentrations (n = 10) were within ± 1% of the certified values. Standards were obtained from Tritisol, Merck and were prepared by spiking water samples. Three replicates of each sediment sample were analyzed and the values were averaged. Estimated precision was: Cd, 10%; Co, 10%; Cu, 7%; Fe, 10%; Mn, 10%; Ni, 8%; Pb, 9%; Zn, 9%.

RESULTS AND DISCUSSION

Metal concentrations in sediment samples collected from nine locations of San Andres lagoon showed no spatial trend between stations in all four seasons. We therefore averaged the metal concentrations in every season; they are presented in Table 1. The concentrations of Cd, Ni, Mn, Co, Pb and Zn were nearly constant in all seasons. Copper and Fe concentrations, however, indicated some variation, with highest concentrations of Cu in North-84 and of Fe in Rain-84 season. This was probably due to the involvement of Cu and Fe in natural weathering, erosion, transportation and biogeochemical processes (Berner and Berner 1987).

A comparison of the average metal concentrations in water and the oyster Crassostrea virginica with sediments analyzed here is given in Table 2. Metal concentrations in sediments in Table 2 are means for all stations and all seasons. The concentrations of metals in water were found in $\mu g\ kg^{-1}$, whereas in oysters and sediments the concentrations were in $mg\ kg^{-1}$. This indicates that relative to water, metals are accumulated in sediments as well as in oysters. Cobalt was detected only in sediment samples.

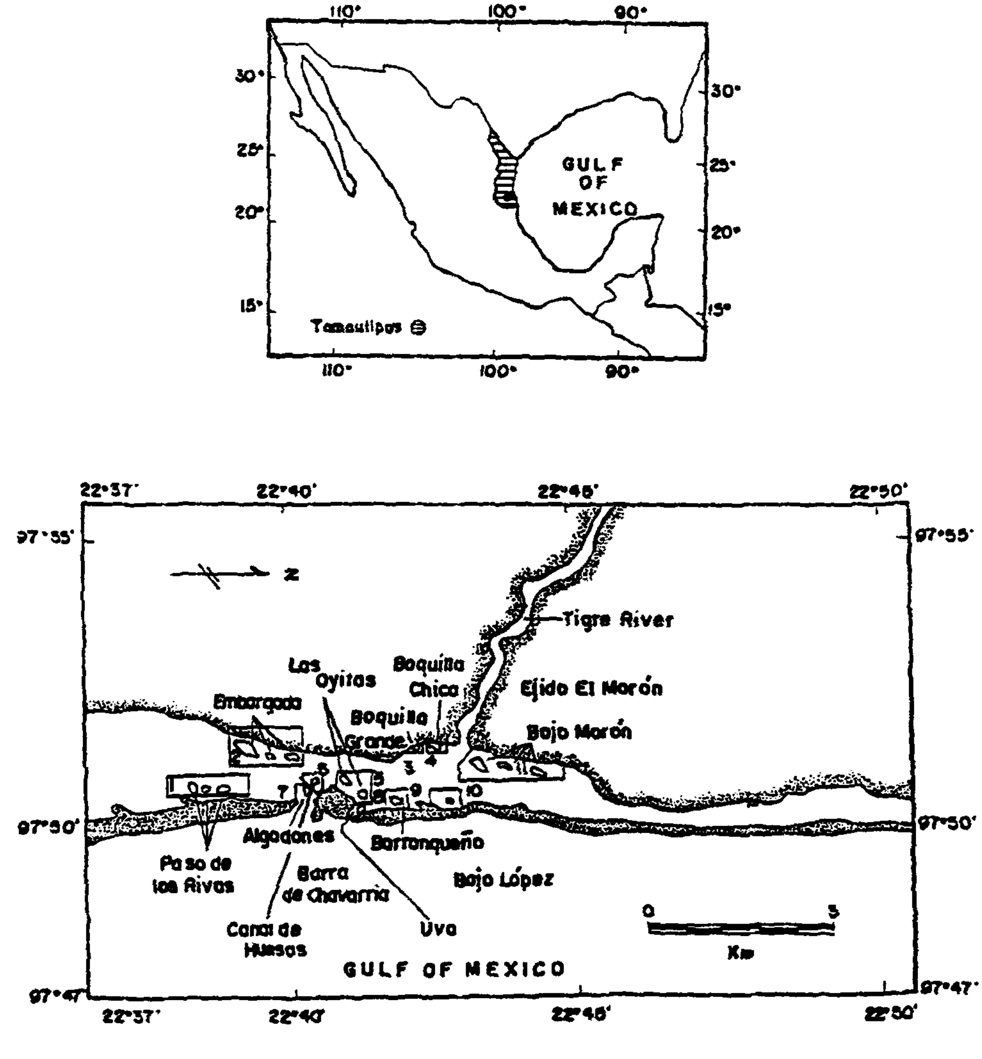

Figure 1 San Andres Lagoon, Tamaulipas, Mexico, Sampling Stations.

Table 1. Metal concentrations in sediments from San Andres Lagoon, Tamaulipas, Mexico taken during several seasons.

Season	Min.	Max.	Mean	SD
		CADMIUM		
I	0.76	1.49	1.08	0.23
II	0.45	1.34	0.97	0.35
III	0.49	1.95	1.08	0.46
IV	0.11	1.81	1.32	0.50
		COPPER		
I	0.98	4.55	2.91	0.99
II	4.66	18.6	7.99	4.65
III	1.49	12.9	5.79	3.85
IV	0.58	5.68	2.72	1.56
		IRON		
I	495	3300	1820	923
II	600	1320	973	290
III	60	2770	1580	838
IV	75	2580	1220	847
		MANGANESE		
I	90	1820	313	432
II	60	285	201	185
III	75	360	167	100
IV	60	285	147	72
		NICKEL		
I	4.91	10.0	6.86	1.65
II	2.50	6.18	4.59	1.46
III	3.17	8.61	5.95	1.85
IV	2.31	9.48	6.42	1.91
		LEAD		
I	6.92	17.9	12.2	2.85
II	6.59	15.9	11.9	3.14
III	7.13	21.6	11.4	4.37
IV	8.46	14.3	11.8	2.68
		ZINC		
I	6.30	16.3	11.0	2.87
II	6.91	16.2	9.67	3.03
III	3.37	16.6	11.0	4.35
IV	1.48	15.8	8.82	4.97
		COBALT		
I	4.20	6.63	5.20	1.10
II	2.07	5.30	4.05	0.94
III	2.65	6.18	4.36	1.35
IV	3.24	6.62	5.42	3.24

I:rain-84; II:north; III:dry; IV:rain-85
SD: Standard Deviation

Table 2. Average concentrations of metals in water ($\mu g\ kg^{-1}$), oyster <u>Crassostrea virginica</u> (mg kg^{-1}, dry weight) and sediments (mg kg^{-1}, dry weight).

Metals	Water[a]	Oyster[b]	Sediments
Cd	0.33	2.55	1.11
Cu	1.82	48.3	4.85
Fe	23.4	64.1	1400
Mn	0.72	27.4	207
Co	ND	ND	4.76
Ni	1.08	3.40	5.96
Pb	1.38	5.85	11.8
Zn	5.12	3180	10.1

a) Vazquez et al. 1993a; b) Vazquez et al. 1991;
ND- Not detected

A correlation of metal concentrations between water and oyster gives ratios of 1:4000 for Cd, Fe, Ni, Pb; 1:32,000 for Cu, Mn; and 1:621,000 for Zn. A correlation between water and sediment samples is 1:4000 for Cd, Cu, Ni, Pb, Zn; 1:60,000 for Fe; and 1:287,000 for Mn. These ratios suggest that Cd, Ni and Pb are equally distributed between oyster tissue and sediments, while Cu and Zn accumulate more in the oyster than in sediments. This is related to the active uptake of Cu and Zn by oysters (Presley et al. 1990). The concentrations of Fe and Mn are higher in sediments than in oysters. Iron and Mn are known to adsorb strongly on sediment particles (Morel 1983).

We found that the concentrations of Cd, Cu, Co, Fe, Mn, Ni, Zn, and Pb in sediments of San Andres lagoon were nearly constant during a period from August 1984 to June 1985. A comparison of metal concentrations in water, oyster (<u>Crassostrea virginica</u>) and sediments of this lagoon indicates that metals are enriched in sediments as well as in oysters, relative to levels in water.

Acknowledgments. This work was supported by the UNAM (project 132). V.K. Sharma gratefully acknowledges the support by Center for Coastal Studies, Texas A & M University, Corpus Christi, Texas, U.S.A.

REFERENCES

Berner EK, Berner RA (1987) The global water cycle. Prentice Hall, New Jersey

Brooks JM (1989) Analyses of bivalves and sediments of organic chemicals and trace elements from Gulf of Mexico estuaries. Final Rep. for NOAA's National Status and Trends Program, Rockville, MD, p704

Bruland KW, Bertine K, Koide M, Goldberg ED (1974) History of metal pollution in Southern California coastal zone. Environ Sci Technol 8:425-435
Clark RB (1986) Marine pollution. Claredon Press, Oxford, London
Forstner U, Wittman G (1981) Metal pollution in the aquatic environment. Springer Verlag, New York
Goldberg ED, Hodge V, Koide M, Griffin J, Gamble E, Bricker OP, Matisoff G, Holdren G.R, Braun R (1978) A pollution history of Chesapeake Bay. Geochim Cosmochim Acta 42:1413-1419
Morel FMM (1983) Principles of aquatic chemistry. John Wiley, New York
Paez OF, Botello AV, Villanueva S (1986) Heavy metals in Coatzacoalcos estuary and Ostion lagoon. Mar Pollut Bull 11:516-519
Presley BJ, Taylor RJ, Boothe PN (1990) Trace metals in Gulf of Mexico oysters. Sci of the Total Environ. 97-98: 551-593
Vazquez GF, Aguilera LG, Delgado HD, Marquez GA (1990) Trace and heavy metals in the oyster, Crassostrea virginica, San Andres lagoon, Tamaulipas, Mexico. Bull Environ Contam Toxicol 45: 907-914
Vazquez GF, Sanchez H, Alexander, Delgado D (1991) Disribution of Ni, V and petroleum hydrocarbons in recent sediments from the Veracruz coast, Mexico. Bull Environ Contam Toxicol 46:774-777
Vazquez GF, Delgado HD, Huerta CJD, Aguilera LG, Sharma VK (1993a) Trace and heavy metals in San Andres lagoon, Tamaulipas, Mexico water. Environ Int 19:71-77
Vazquez GF, Sanchez GM, Sharma VK (1993b) Trace metals in oyster, Crassostrea virginica, of Terminos lagoon, Campeche, Mexico. Mar Pollut Bull (In press)