Metals in some Lagoons of Mexico

Felipe G. Vázquez,1 Virender K. Sharma,2 V.H. Alexander,1 and C.A. Frausto1

1Instituto de Ciencias del Mar y Limnología, UNAM. Cd. Universitaria; 2Center for Coastal Studies, Texas A&M University, Corpus Christi, Texas

The concentrations of metals, Cd, Cu, Fe, Mn, Ni, Pb, and Zn were determined in some lagoons to establish the level of metal pollution. The lagoons studied were Alvarado lagoon, Veracruz; San Andres lagoon, Tamaulipas; and Terminos lagoon, Campeche. The concentrations were determined in water, oyster (Crassostrea virginica), and sediments. Metals were accumulated in either oysters or sediments. Cu and Zn were higher in oysters and Fe and Mn were higher in sediments. The results in water samples were compared with the limit established by the Secretaria de Ecologia and Desarrollo Urbano Report and briefly discussed. — Environ Health Perspect 103(Suppl 1):33–34 (1995)

Key words: heavy metals, water, sediments, oyster (Crassostrea virginica), adsorption, uptake

Introduction

Metal concentrations in the environment are controlled by various processes such as adsorption onto particle surfaces, coprecipitation with solid phases, and cycles of micronutrients (1). High concentrations of metals are generally found in coastal zones due to the fluvial and industrial effluents. Once metals are in the coastal water, they either concentrate in sediments and organisms or remain in the water column, depending on physicochemical conditions: salinity, temperature, particle size, and pH, and on physiological conditions: sex, age, and growth (2). Therefore, to understand the role of metals in biochemical and geochemical processes, it is important to determine their concentrations in water, organisms, and sediments.

For the past several years, we have been interested in determining trace and heavy metal concentrations in lagoons in Mexico to establish levels of metal pollution (3–7). The lagoons studied were San Andres lagoon, Tamaulipas; Terminos lagoon, Campeche; and Alvarado lagoon, Veracruz. These lagoons are in the south of the Gulf of Mexico (Figure 1) and are important ecosystems due to biological diversity; valuable fish, oyster, and wildlife resources; and proximity to present and proposed industries. In the present article, we summarize the concentration of metals — Cu, Cd, Fe, Mn, Ni, Pb, and Zn—in water, oyster (Crassostrea virginica), and sediments of these lagoons. The results in the water column are compared to the limit established for coastal water of Mexico, SEDUE (8).

Materials and Methods

The detailed procedures for samples collection and analysis are given elsewhere (5–7). In brief, the water samples were taken in Van Dorn bottles previously soaked in aqua regia. All samples were filtered through 0.45 μm filters (Millipore Corporation) and stored in 1000 ml plastic bottles containing 1 ml of concentrated HNO₃ to acidify the samples to pH 1.6 to 2.0. Metal concentrations in these samples were analyzed by the ion exchange column technique (9).

The oysters were collected manually, stored in plastic bags and frozen at 20°C. The complete animals (without shell) were freeze-dried, the sample size usually being 1 g. Extractions of metals were performed using acid digestion bombs (with a teflon cup) with 3 M HNO₃ and HCl (10).

The sediment samples were carefully taken with an acid-washed plastic spatula from the surface 4 cm central portion of the grab to avoid contamination, placed in plastic bags, and stored frozen. One- to two-centimeter strata were analyzed. The metals in sediments were digested successfully with HCl, HNO₃, HClO₄, HF, and heated at total dissolution (11).

Metal concentrations were determined with a Perkin Elmer 2380 atomic absorption spectrophotometer equipped with HGA-400 graphite furnace. Standards were obtained from Tritisol (Merck) and prepared by spiking water samples. Three replicates of each sample were analyzed and the values averaged. Estimated precision was approximately 10%.

Results and Discussion

Metal concentrations in water, oyster (Crassostrea virginica), and sediments in different lagoons are given in Table 1. The comparison of metal concentrations in water samples to the limit established by Secretaria de Ecologia and Desarrollo Urbano (SEDUE) Report (8) for estuarine water in Mexico is also given in Table 1. Cadmium concentration in San Andres lagoon water is higher by an order of magnitude than that in the Alvarado and Terminos lagoons, while it is lower than the limit established by SEDUE. The concentrations of nickel and

Figure 1. Study areas of lagoons in Mexico.
Andres value zincare either lower than or equal to the SEDUE limit. Lead concentration in oyster, Crassostrea virginica, San Andres lagoon (5). Metal concentrations, except zinc, in oysters of San Andres lagoon are lower than in Terminos lagoon (Table 1). The discharges of oil industries and of the Usumacinta-Grijalva river system (the largest in Mexico and second largest in Gulf of Mexico) influence the coastal water of Terminos lagoon and may be responsible for high accumulation of metals in oysters.

Table 1 summarizes metal levels in sediments of Alvarado and San Andres lagoons. Metal concentrations were higher in Alvarado than in San Andres lagoon. This is related to adsorption of metals on iron-enriched sediment particles (14). Metal concentrations in water, organisms, and sediments of San Andres lagoon indicate 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. The active uptake of Cu and Zn by oyster is known (15). As expected, we have found higher concentrations of Fe and Mn in sediments than in oysters (14). Work on measurements of metal concentrations in Alvarado and Terminos lagoons is in progress to make a similar comparison.

| Lagoon          | Cd  | Cu  | Fe  | Mn  | Ni  | Pb  | Zn  |
|-----------------|-----|-----|-----|-----|-----|-----|-----|
| Alvarado         | 0.01| 1.01| 72.8| 0.84| 0.93| 0.85| 2.37|
| San Andres       | 0.33| 1.82| 23.4| 0.72| 1.08| 1.38| 5.12|
| Terminos         | 0.02| 1.76| 61.9| 0.38| —   | —   | —   |
| SEDUE            | 1.00| —   | —   | 1.08| 1.00| 9.76| —   |
| Oyster, Crassostrea virginica |     |     |     |     |     |     |     |
| San Andres       | 2.51| 48.3| 64.1| 27.5| 3.39| 5.81| 3120|
| Terminos         | 4.11| 326 | 949 | 37.9| —   | 8.8 | 628 |
| Sediments        |     |     |     |     |     |     |     |
| Alvarado         | —   | 18.5| 4.59*| 10.1| 69.5| 29.9| 88.2|
| San Andres       | 1.11| 4.86| 0.14*| 207 | 5.96| 11.8| 10.1|

* in % of the sample. **This work. Vazquez et al (5). Paez et al (12). SEDUE, 1986 (8). Vazquez et al (3). Vazquez et al (8). Rosales et al (13). Vazquez et al (7).

zinc are either lower than or equal to the SEDUE limit. Lead concentration in San Andres lagoon is somewhat higher than the value reported in SEDUE. The higher lead is related to an anthropogenic input in the San Andres lagoon (5).

REFERENCES

1. Sadiq M. Toxic Metal Chemistry in Marine Environments. New York: Marcel Dekker, 1992.
2. Clark RB. Marine Pollution. Oxford: Clarendon Press, 1986.
3. Vazquez FG, Aguiler LG, Delgado HD, Marquez GA. Trace and heavy metals in oyster, Crassostrea virginica, San Andres lagoon, Tamaulipas, Mexico. Bull Environ Contam Toxicol 45:907-914 (1990).
4. Vazquez FG, Sanchez H, Alexander V, Delgado HD. Distribution of Ni, V, and petroleum hydrocarbons in recent sediments from the Veracruz coast, Mexico. Bull Environ Contam Toxicol 46:774-777 (1991).
5. Vazquez FG, Delgado HD, Huerta CJD, Aguiler LG, Sharma VK. Trace and heavy metals in San Andres lagoon, Tamaulipas, Mexico water. Environ Int 19:71-77 (1993).
6. Vazquez FG, Sanchez GM, Sharma VK. Trace metals in oyster Crassostrea virginica of Terminos lagoon, Campeche, Mexico. Mar Pollut Bull 26:398-399 (1993).
7. Vazquez FG, Aguiler LG, Sharma VK. Metal in sediments of San Andres lagoon, Tamaulipas, Mexico. Bull Environ Contam Toxicol 52:382-387 (1994).
8. SEDUE (Secretaria de Ecologia y Desarrollo Urbano). Reglamento para la prevencion y control de la contaminacion de aguas. Mexico City, Mexico: SEDUE, 1986;1-40 (In Spanish).
9. Bruland KW, Coale KH. Analysis of seawater for dissolved cadmium, copper, and lead: an intercomparison of voltametric and atomic absorption methods. Mar Chem 17:285-300 (1985).
10. Hamilton EL. The chemical laboratory and trace element analyses. In: Element Analyses of Biological Material: Current Problems and Techniques with Special to Trace Elements. Technical Report Series No. 197. Vienna: International Atomic Energy Agency. 14:303-315 (1980).
11. Bruland KW, Berrine K, Koide M, Goldberg ED. History of metal pollution in Southern California coastal zone. Environ Sci Technol 8:425-435 (1974).
12. Paez OF, Valdez LD, Alexander VH, Fernandez PH. Trace metals in the fluvial systems of Terminos lagoon. Mar Pollut Bull 11:294-297 (1987).
13. Rosales HL, Carranza EA, Alvarez RV, Sedimentological and chemical studies in sediments from Alvarado lagoon system, Veracruz, Mexico. An Inst Cienc Mary Linnmol Univ Nat Auton Mexico 9:141-160 (1986).
14. Morel MM, Hering GJ. Principles and Applications of Aquatic Chemistry. New York: John Wiley and Sons, 1993.
15. Presley BJ, Taylor R, Boothe PN. Trace metals in Gulf of Mexico oysters. Sci Tot Environ 97-98:551-593 (1990).