Bull. Environ. Contam. Toxicol. (1990) 44:784–789

Environmental Contamination and Toxicology

Lead and Cadmium Concentrations in Marine Organisms from the Tarragona Coastal Waters, Spain

M. Schuhmacher,[1] M. A. Bosque,[1] J. L. Domingo,[1] and J. Corbella[2]

[1]Laboratory of Toxicology and Biochemistry, School of Medicine, University of Barcelona, San Lorenzo 21, 43201 Reus and [2]Department of Toxicology, School of Medicine, University of Barcelona, Casanova 143, 08036 Barcelona, Spain

Lead and cadmium are now recognized to be two of most important heavy metal contaminants of the marine environment (Ketchum et al. 1975; Anderson 1978; Martincic et al. 1984). Lead is a cumulative toxic element that has no known beneficial or desirable nutritional effect on fish or other animals (Holcombe et al. 1976). Despite the fact that only about 10% of lead ingested with food is absorbed from the digestive tract of mammals, this amount poses a serious threat because of ever increasing contamination of food (Zakrzewska 1988). In like manner, increased industrial use of cadmium and environmental pollution with cadmium-related waste products has provoked an appropiate concern about the potential health consequences of human exposure to this highly toxic metal (Pocock et al. 1988). Both lead and cadmium may severely interfere with the ecology of the aquatic environment (Bryan 1971).

The Tarragona coastal area (Catalonia, NE Spain) is a biologically productive and physically diverse marine ecosystem, with a very important commercial fishing industry. Two rivers, the Ebro (South) and the Francoli (North) flow into the Mediterranean Sea at the Tarragona coastal waters, which are subjected to large loads of toxic industrial residues (including heavy metals). Although considerable data have been accumulated on the distribution and levels of heavy metals in marine species from different areas of the Mediterranean Sea, data from the Tarragona coastal area are not available in the literature.

The purpose of the present study was to determine the distribution and concentrations of lead and cadmium in the marine species commonly consumed by the population of Tarragona, as well as to learn whether these levels may constitute a health hazard for the consumers. Lead and cadmium were measured in 23 commercially significant marine species from the Tarragona coastal waters.

MATERIALS AND METHODS

The species investigated were randomly purchased from local

Send reprint requests to Jose L. Domingo at the above address.

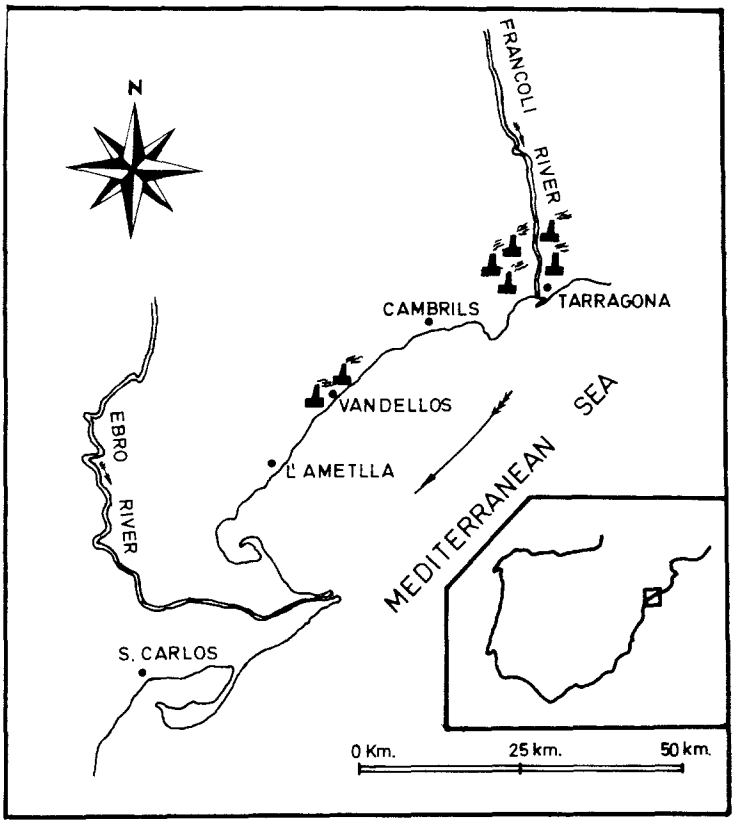

Figure 1. Location of the sampling stations.

fishermen in four fishing ports along the Tarragona coast: Tarragona and Cambrils (North), and L'Ametlla and S.Carlos (South) (Figure 1). The specimens were then packed in polyethylene bags and brought fresh to the laboratory for analysis.

The specimens investigated included: Sardina pilchardus, Engraulis encrasicholus, Mullus barbutus, Solea solea, Merluccius merluccius, Pagellus erythrinus, Micromesistius poutassou, Trisopterus minutus, Cepola rubescens, Squilla mantis, Pallinurus vulgaris, Penaeus kerathurus, Nephrops novegicus, Carcinus maenas, Murex brandaris, Mytilus edulis, Ostrea edulis, Tapes decussatus, Venus gallina, Pecten maximus, Loligo vulgaris, Seppia officinalis, and Octopus vulgaris. Some specimens were not available at all four fishing ports.

To get representative samples, composites were prepared by taking 25 to 33 specimens of each species, with the exception of lobsters where only six were used. The samples of molluscs and crustaceans were prepared by removing the shells and draining the

contents for 10 min. Prior to digestion, these samples were eviscerated and homogenized. Muscle tissues of fish were also homogenized prior to digestion. Tissue moisture was determined by drying the wet samples at 135° C until constant weight was attained (Crisetig et al. 1985; Ober et al. 1987). For the analysis of lead and cadmium, tissues of animals were heated at 110°C for 18 hr with 65% nitric acid (Suprapur Merck, Darmstadt, FRG). Lead was determined using a Perkin-Elmer 5100 Zeeman spectrophotometer and Spectra A-30 graphite furnace. Cadmium concentrations were measured in a computer-controlled sequential inductively coupled plasma spectrometer (Jobin Yvon JY 38 VHR). All necessary precautions were adopted to avoid possible contamination of the samples. The nonparametric ANOVA Kruskal-Wallis and the Mann-Whitney U test were used to evaluate statistical significance. A probability of 0.05 or less was considered significant.

RESULTS AND DISCUSSION

The mean values for lead and cadmium concentrations in the marine organisms included in this study are summarized in Tables 1 and 2. The results show that both metals are accumulated to a greater or lesser extent by the 23 species investigated. Slight significant differences in the levels of lead or cadmium were found for certain species from the different ports (Tables 1 and 2). It was probably due to the geographical closeness among the four locations. However, the specimens purchased in S. Carlos and L'Ametlla, which were probably collected close to the mouth of the Ebro, showed lead and cadmium levels higher than those purchased in Tarragona or Cambrils. Moreover, lead and cadmium concentrations were higher in the specimens purchased in Cambrils than in those purchased in Tarragona. It may be due to the fact that the industrial wastes of Francoli are carried away by the currents running from north to south (Fig.1). In general, crustacean and molluscan species showed higher concentrations of lead and cadmium than the remaining species (Tables 1 and 2). It must be remembered that fish may move and inhabit different areas. A remarkable relationship between heavy metal concentrations in marine organisms and the levels of these metals in sediments has been established by several authors (Genest and Hatch 1981; Lytle and Lytle 1982; Wiener et al. 1984).

It is important to establish the levels of heavy metals in marine organisms to learn whether these levels may constitute a health hazard. The marine species studied here are all of commercial interest and represent an important food source for the population of Tarragona and Catalonia. The levels of lead and cadmium found in this study did not exceed the allowable maximum concentration of these metals according to the current food standard regulation for Spain (Boletín Oficial del Estado, 1985), with the exception of mean cadmium concentrations in C. maenas, P. maximus, P. vulgaris and M. brandaris which exceeded the maximun

Table 1. Lead concentrations (µg/kg wet weight) in marine organisms from four locations on the Tarragona coast, Spain[1]

Species	Tarragona	Cambrils	L'Ametlla	S.Carlos	P[2]
S. pilchardus	86.0±43.5	283.2±156.0	165.5±16.8	138.7±31.9	NS
E. encrasicholus	193.8±21.3	175.5±46.0	237.3±25.8	337.8±81.2	NS
M. barbutus	457.0±137.7	260.3±75.4	682.7±187.1	317.1±46.0	NS
S. solea	96.8±32.6^{a}	147.7±28.8^{a}	345.2±10.6^{b}	476.0±56.4^{c}	0.001
M. merluccius	80.0±68.7^{a}	115.8±56.0^{a}	1062.0±359.8^{b}	238.2±152.7^{ab}	0.05
P. erythrinus	157.0±20.5	201.3±82.0	315.7±20.8	256.2±61.4	NS
M. poutassou	210.2±88.4	73.3±53.1	NA	275.2±10.3	NS
T. minutus	446.4±122.7	252.0±34.3	1014.5±367.6	234.7±41.1	NS
C. rubescens	196.5±47.2^{ab}	200.1±43.0^{a}	934.5±195.7^{a}	83.0±20.2^{b}	0.01
S. mantis	16.4±6.3^{a}	183.3±47.1^{bd}	1077.4±297.7^{c}	621.7±182.7^{dc}	0.01
P. vulgaris	NA	ND	583.0±27.0	1156.1±651.0	NS
P. kerathurus	NA	228.1±81.5	29.3±10.2	938.7±148.9	NS
N. novegicus	161.0±14.4	NA	126.2±14.4	547.8±98.4	NS
C. maenas	469.7±133.9^{ac}	1426.7±346.6^{b}	254.7±29.8^{a}	1638.2±439.1^{ab}	0.01
M. brandaris	465.0±164.3	619.3±192.4	288.0±131.8	274.0±40.6	NS
M. edulis	499.5±33.6^{a}	825.3±258.9^{ab}	997.2±219.2^{b}	339.8±91.6^{a}	0.05
O. edulis	NA	232.3±68.9	NA	214.0±49.6	NS
T. decussatus	832.7±538.4	2387.2±592.6	803.0±284.8	267.5±21.5	NS
V. gallina	862.5±330.4	455.4±70.4	788.2±161.0	401.2±148.2	NS
P. maximus	NA	509.0±15.0	NA	1942.0±411.7	NS
L. vulgaris	306.2±18.6	418.3±42.0	307.7±25.1	390.7±56.8	NS
S. officinalis	337.8±8.9^{ac}	465.0±19.7^{b}	674.0±92.9^{a}	269.2±54.2^{c}	0.01
O. vulgaris	400.2±32.9^{a}	344.7±22.6^{a}	356.0±16.6^{a}	259.5±14.1^{b}	0.01

[1]All values are shown as means ± SEM; NA indicates species not available in that location; ND, not detected; detection limit 15 µg/kg. Different superscripts indicate statistically significant differences.

[2]ANOVA P value; NS, not significant.

concentrations specificied for this metal (1 µg/kg wet weight). To date, no other reports concerning heavy metal levels in marine organisms of the Tarragona coastal area have been published. The concentrations of lead and cadmium reported here are not substantially different from those reported for comparable species sampled in other Mediterranean areas (Crisetig et al. 1985; Medina et al. 1986). Moreover, these concentrations were also similar or even lower than those reported by other authors for species from other latitudes (Lytle and Lytle 1982; Smith et al. 1986; Ober et al. 1987; Rincon et al. 1988).

In summary, the levels of the lead and cadmium determined in the species collected in the Tarragona coastal area, an area particularly exposed to pollution inputs from the Ebro and Francoli Rivers, would not mean a health hazard for consumers.

Table 2. Cadmium concentrations (µg/kg wet weight) in marine organisms from four locations on the Tarragona coast, Spain[1]

Species	Tarragona	Cambrils	L'Ametlla	S.Carlos	P[2]
S. pilchardus	330.9±57.2^{a}	21.6±5.4^{b}	86.4±3.9^{a}	939.0±438.2^{a}	0.01
E. encrasicholus	ND^{a}	228.0±10.1^{b}	222.4±115.4^{b}	ND^{a}	0.001
M. barbutus	180.3±15.2^{a}	652.4±80.7^{b}	471.9±189.6^{bc}	384.5±32.2^{c}	0.01
S. solea	16.3±3.2^{a}	296.4±101.7^{b}	224.5±25.7^{b}	ND^{c}	0.001
M. merluccius	146.8±40.5^{a}	320.1±29.0^{b}	12.4±5.7^{a}	27.2±10.3^{a}	0.01
P. erythrinus	ND^{a}	82.4±7.7^{b}	188.9±14.0^{c}	139.8±8.5^{d}	0.001
M. poutassou	110.8±45.9	253.7±38.2	NA	554.7±366.1	NS
T. minutus	316.3±51.7^{a}	107.5±13.3^{b}	12.2±7.9^{c}	587.5±417.9^{ab}	0.001
C. rubescens	32.7±7.6^{a}	151.6±32.1^{bc}	1156.9±984.3^{b}	75.1±19.4^{ac}	0.01
S. mantis	123.1±19.7^{a}	236.5±26.6^{b}	312.2±68.4^{b}	595.3±67.8^{c}	0.01
P. vulgaris	NA	1804.3±1045.0	ND	502.1±26.7	NS
P. kerathurus	NA	10.9±4.8	17.6±3.4	13.9±5.0	NS
N. novegicus	184.4±40.7^{a}	NA	189.7±11.4^{a}	940.0±248.5^{bc}	0.05
C. maenas	195.0±52.1	334.4±72.5	6449.9±3733.2	166.7±25.3	NS
M. brandaris	863.4±314.2^{ab}	68.5±11.4^{b}	929.8±384.4^{a}	1616.5±874.0^{a}	0.05
M. edulis	283.4±110.7	142.7±20.9	65.4±14.3	626.1±460.5	NS
O. edulis	NA	807.6±130.5	NA	405.6±81.6	NS
T. decussatus	25.1±7.1^{a}	297.9±148.7^{b}	133.9±35.9^{b}	93.9±57.0^{ab}	0.05
V. gallina	211.1±25.3^{a}	321.7±113.1^{ac}	115.9±12.2^{b}	114.1±9.3^{bc}	0.05
P. maximus	NA	201.7±180.5	NA	1828.5±583.8	NS
L. vulgaris	51.7±14.3^{a}	ND^{b}	109.0±25.2^{a}	ND^{b}	0.001
S. officinalis	25.5±15.1	ND	ND	ND	NS
O. vulgaris	30.0±22.7	ND	ND	ND	NS

[1]All values are shown as means ± SEM; NA indicates species not available in that location; ND, not detected; detection limit 2 µg/kg. Different superscripts indicate statistically significant differences.
[2]ANOVA P values; NS, not significant.

Acknowledgments. Supported by "Caixa of Barcelona Foundation". M.A. Bosque was supported by a research fellowship from the DGICYT, Spain. The authors thank the Servei d'Espectroscopía, University of Barcelona for excellent technical assistance.

REFERENCES

Anderson RV (1978) The effects of lead on oxygen uptake in the crayfish, Orconectes virilis. Bull Environ Contam Toxicol 20: 394-400

Boletín Oficial del Estado (1985) Separatas del Boletín Oficial del Estado Español Nº 137. Gaceta de Madrid

Bryan GW (1971) The effects of heavy metals (other than mercury) on marine and estuarine organisms. Proc Roy Soc London (B) 117: 389-410

Crisetig G, Poletti R, Viviani R (1985) Toxic metal distribution in marine organisms from sea area opposite the Po delta. Arch Vet Ital 36: 65-68

Genest PE, Hatch WI (1981) Heavy metals in Mercenaria mercenaria and sediments from the New Bedford Harbor region of Buzzard's Bay, Massachusetts. Bull Environ Contam Toxicol 26: 124-130

Holcombe GW, Benoit DA, Leonard EN, McKim JM (1976) Long-term effects of lead exposure on three generations of brook trout (Salvelinus fontinalis). J Fish Res Board Can 33: 1731-1741

Ketchum BH, Zitko V, Saward D (1975) Aspects of heavy metal and organohalogen pollution in aquatic ecosystems. In: McIntyre AD, Mills CF (eds) Ecological Toxicology Research. Effects of Heavy Metal and Organohalogen Compounds. Plenum Press, New York, pp 75-85

Lytle TF, Lytle JS (1982) Heavy metals in oysters and clams of St. Louis Bay, Mississippi. Bull Environ Contam Toxicol 29: 50-57

Martincic CD, Nurnberg HW, Stoeppler M, Branica M (1984) Bioaccumulation of heavy metals by bivalves from Limfjord (North Adriatic Sea). Mar Biol 81: 177-188

Medina J, Hernández F, Pastor A, Beferull JB and Barberá JC (1986) Determination of mercury, cadmium, chromium and lead in marine organisms by flameless atomic absorption spectrophotometry. Mar Poll Bull 17: 41-44

Ober AG, González M, Santa Maria I (1987) Heavy metals in molluscan, crustacean, and other commercially important Chilean marine coastal water species. Bull Environ Contam Toxicol 38: 534-539

Pocock SJ, Delves HT, Ashby D, Shaper AG, Clayton BE (1988) Blood cadmium concentrations in the general population of British middle-aged men. Human Toxicol 7: 95-103

Rincón F, Zurera G, Pozo R (1988) Lead and cadmium concentrations in red crayfish (Procamburus clarkii, G.) in the Guadalquivir river marshes (Spain). Arch Environ Contam Toxicol 17: 251-256

Smith D, Stephenson M, Flegal A (1986) Trace metals in mussels transplanted to San Francisco bay. Environ Toxicol Chem 5: 129-138

Wiener JG, Jackson GA, May TW, Cole BP (1984) Longitudinal distribution of trace elements (As, Cd, Cr, Hg, Pb and Se) in fishes and sediments in the upper Mississippi river. In: Wiener JG, Anderson RV, McConville DR (eds). Contaminants in the Upper Mississippi River. Butterworth, Stoneham, MA, pp 139-170

Zakrzewska M (1988) Effect of lead on postnatal development of the bank vole (Clethrionomys glareolus). Arch Environ Contam Toxicol 17: 365-371

Received July 1, 1989; accepted August 28, 1989.