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Heavy Metals in Molluscan, Crustacean, and Other Commercially Important Chilean Marine Coastal Water Species

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Pollution of the marine ecosystem by heavy metal is a worldwide problem, and main sources of metal pollution are represented by domestic sewage, industrial effluents, oil spills, combustion emissions, mining operations, metalurgical activities and garbage dumps(Bryan 1976; Forstner & Wittmann 1979).

Some heavy metals in trace concentrations are normal constituents of marine organisms, but at higher levels they are potentially toxic and may severely interfere with the ecology of the aquatic environment (Bryan 1971). Because their ability to concentrate pollutants of various kinds from their environments (Watling 1983; Thrower & Eustace 1973) it is important to have a knowledge about the changes in the metal levels that should be considered within a normal range, and to know how much their concentrations may be increased above these levels before the effects can be detected and commercial species become unsuitable as food.

Although considerable data have been accumulated on the distribution and levels of heavy metals in the marine environment, data reported about south eastern Pacific coastal marine species are very scarce and only very few results are available in the literature.

The work reported here is part of a general program to monitor the marine chemical pollution along the Chilean coast. The present investigation was designated to provide information on the nature and levels of the heavy metals present in the marine species commonly consumed by the population, and to learn whether these levels may constitute a hazard to consumers.

We report here the typical contents of 10 heavy metals in 12 commercially significant marine species from the Chilean coastal waters (Valparaíso, Concepción and Puerto Montt). The analyzed species included 7 molluscs, 3 crustacea, and 2 other shellfish species of wide consumption. The metals chosen for analysis were copper, zinc, cadmium, lead, mercury, nickel, antimony, selenium, iron and chromium.

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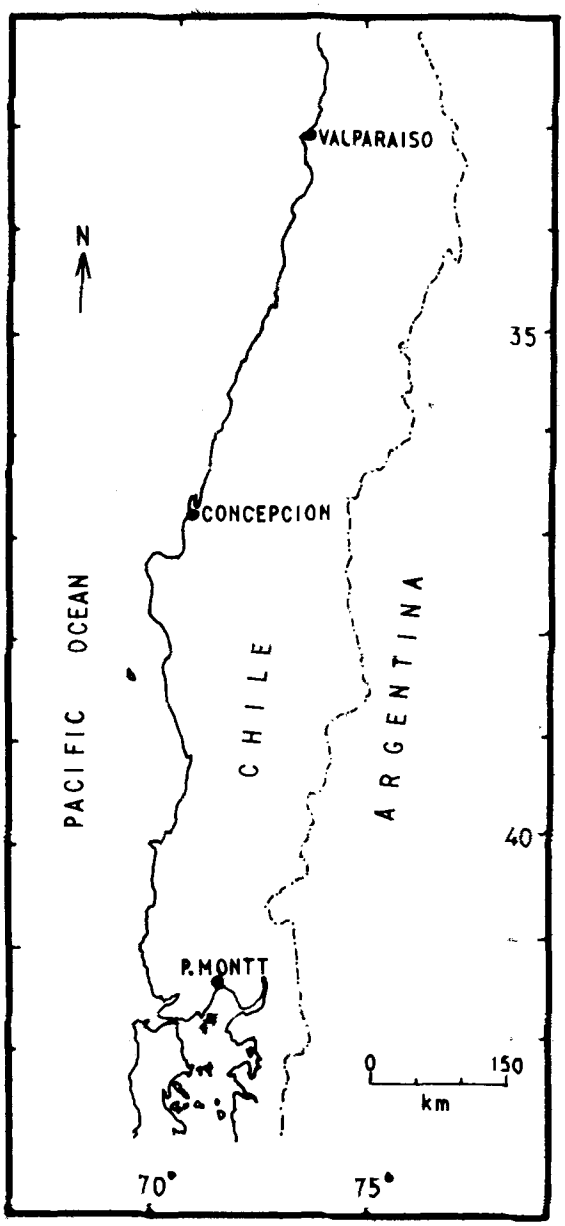

Figure 1. Sampling sites along the Chilean coast

MATERIALS AND METHODS

The glassware utilized here was soaked in dtergent, rinsed with water, soaked in 10% nitric acid, rinsed with distilled water, and kept in the oven at 110 C till needed. The reagent used were analytical grade or equivalent, and pretested for possible heavy metal contamination.

The species investigated were randomly collected by local fishermen,from the lower shores of sites along the coast of Valparaíso, Concepción and Puerto Montt in the period April 1985 to September 1985. The collection sites are shown in Figure 1.

The specimens were brought fresh to the laboratory and analyzed upon arrival. Whole specimens including shells, were measured and weighted. Only edible parts were analyzed.

The specimens investigated included: Mytilus edulis chilensis (mussel), Aulacomya ater (ribbed mussel), Chlamys (Argopecten) purpurata (scallops), Concholepas concholepas (abalone), Ameghinomya antiqua (clam), Thais chocolata (sea snail), Loxechibus albus (sea urchin), Cancer edwardsii (common crab), Pleuroncodes monodon (baby rock lobster), Heterocarpus reedi (shrimp), Mesodesma donacium (no simil in the U.S.), and Pyura chilensis (sea-squirt).

Eight of the 12 examined species were collected in the bay of Valparaíso, 2 in the bay of Concepción (M. chilensis and A. ater), and 2 were from Puerto Montt (L. albus and P. chilensis).

In order to get representative samples, composites were prepared by taking 24 to 30 specimens of the small species, and 4 to 8 of the bigger ones. The samples were prepared by removing the shells and draining the contents for 10 minutes. Prior to the digestion, the samples were eviscerated and homogenized. Tissue moisture was determined by drying the wet samples at 135 C until constant weight was attained.

The digestion for all metals consisted of treatment of 35 g dried tissue at 150 C with conc. nitric acid (10 mL) and conc. sulfuric acid (15 mL). After cooling down to room temperature, 3% hydrogen peroxide (3 mL) was added and the digestion mantained. Additional conc. nitric acid (3 mL) was added and the process repeated until a colorless solution was obtained. The digest was made up to 100 mL and analyzed by AA Spectrophotometry. Heavy metals were determined using a Perkin-Elmer Model 5000 AA Spectrophotometer. Antimony and selenium were determined by hydride generation using a Perkin-Elmer MHS-10 hydride system interfaced to the above mentioned spectrophotometer.

RESULTS AND DISCUSSION

Mean tissue metal concentrations of 10 heavy metals in 7 molluscan, 3 crustacean, and 2 other marine species examined in this study are summarized in Tables 1 and 2. Samples were analyzed in duplicate and the results are expressed in ppm on a dry weight basis. Water contents in the analyzed species are shown to enable comparisons with data published in the literature and that might be expressed on a wet basis.

Marine organisms accumulate a variety of heavy metals that are thought to be essential to life processes, and many of these elements interact with marine biota in varied ways (Bryan 1971).

Table 1. Average concentrations* in ppm (dry weight) of Cu, Fe, Zn, Ni and Se in Chilean shellfish species.

	% Water	Cu	Fe	Zn	Ni	Se
A. antiqua	76.4	8.1	131	65	4.2	<0.01
A. ater	82.0	9.8	206	96	3.4	<0.01
C. concholepas	81.6	21.9	78	56	2.2	<0.01
C. purpurata	81.1	32.7	65	164	n.d.	<0.01
M. chilensis	82.4	9.4	441	86	1.0	<0.01
M. donacium	79.4	24.4	768	45	1.3	<0.01
T. chocolata	61.7	26.3	86	138	0.4	<0.01
C. edwardsii	68.8	31.2	144	464	3.0	<0.01
H. reedi	84.0	16.0	86	47	1.2	<0.01
P. monodon	70.3	9.0	374	36	0.8	<0.01
L. albus	73.4	6.8	60	27	1.8	<0.01
P. chilensis	79.0	10.6	118	39	1.4	<0.01

* Mean value of a sample run in duplicate.
n.d.= not detected

The results presented in Tables 1 and 2 indicate that all the metals , except mercury and selenium are accumulated to a greater or lesser extent by each one of the 12 marine species investigated here. Mercury was not detected in any of the species , and selenium occurs in these organisms only at very low levels (0.01 ppm).

This work was initially centered in species from Valparaíso, but was later extended to species from Concepción and Puerto Montt because these two localities are main production areas for the shellfishes consumed by the Chileans. The bays of Valparaíso and Concepción (Figure 1) are highly urbanized and industrialized areas, and as it would be expected the tissue metal levels of the organisms collected in them are relatively high (Bryan 1971). The placement of oil and metal refineries , together with industries that drain their effluents into rivers that end up in the ocean may well be part of the causes for the heavy metal pollution of these bays. Puerto Montt (Figure 1) by the other hand, is less populated and has a smaller industrial activity than the above mentioned bays, and was included mainly for comparison purposes.

It is important to establish the levels of these heavy metals in the marine species in order to learn whether the levels may constitute a hazard to consumers. The marine species studied here are all of commercial interest and represent an important food source for the Chilean population. A closer examination of the data in Tables 1 and 2 shows that the species are accumulating most notably Zn, Cd, Pb, Cu, Cr and possibly Ni. The concentrations of Zn ranged from 27.4 to 464 ppm, Cd from 0 to 8.2 ppm, Pb from 0 to 32.7 ppm, Cu from 6.8 to 32.7 ppm,Cr from 0 to 2.2 ppm, and Ni from 0 to 4.2 ppm. The levels of Cd,Pb,Cu and Ni are found to be highest in the molluscan species, while Zn and Fe are highest in the crustacea. A comparison of the Cr and Sb concentrations among

Table 2. Average concentrations* in ppm (dry weight) of Pb, Cr, Cd, Sb and Hg in Chilean shellfishes.

A. antiqua	12.6	1.4	2.8	0.08	n.d.
A. ater	18.4	n.d.	3.3	0.01	n.d.
C. concholepas	7.6	n.d.	n.d.	0.05	n.d.
C. purpurata	32.7	2.2	8.2	0.14	n.d.
M. chilensis	13.6	1.0	n.d.	0.02	n.d.
M. donacium	11.4	2.0	1.3	0.05	n.d.
T. chocolata	9.6	0.7	4.9	0.07	n.d.
C. edwardsii	n.d.	0.8	n.d.	0.03	n.d.
H. reedi	12.6	2.2	n.d.	0.03	n.d.
P. monodon	7.6	0.8	n.d.	0.02	n.d.
l. albus	9.8	2.2	1.8	0.01	n.d.
p. chilensis	15.2	2.2	2.4	0.18	n.d.

* Mean value of a sample run in duplicate.
n.d.= not detected

the species , shows that both elements are being accumulated in similar levels by molluscs and crustacea.

The current food standard regulations in Chile (Public Health Department 1982) specify allowable maxima for the quantities of Zn, Cd, Cu, Se and Pb which foods may contain. These maxima are: Zn, 100 ppm; Cd, 0.05 ppm; Cu, 10 ppm; Se, 0.30 ppm; Pb, 2.0 ppm. No maxima have been specified for the other metals. The results presented in Tables 1 and 2 show that some of the species investigated contain levels of Zn, Cd, Cu and Pb that are far above the permitted maxima. The high metal concentrations in some of the species examined here indicate that the contents could be dangerous for the health of consumers (Thrower & Eustace 1973; Eustace 1974). This is especially true in what Cd and Pb is concerned, since these two metals are considered to be the most toxic among the elements studied here. The tissue copper levels were generally lower than the permissible maxima, but 7 of the 12 species exceeded the allowable levels.

We found no other published reports concerning heavy metal contents in Chilean marine species, but refering to results published by other authors for species from other latitudes (Lytle & Lytle 1982; Latouche & Mix 1981; Genest & Hatch 1981; Sadiq et al. 1982) it is possible to quote the tissue metal concentrations shown in Tables 1 and 2 as high. Further studies on heavy metals in Chilean marine species are needed.

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