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The Influence of Salinity on Toxicity of Cadmium and Chromium to the Blue Crab, *Callinectes sapidus*

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Heavy metals are of increasing concern as pollutants of the coastal and estuarine environment. Cadmium and chromium salts are two of many which may be present in effluents discharged from industrial processes, and are toxic in sufficient concentrations. Effects of cadmium and/or chromium on decapod crustaceans have been studied by EISLER (1971), COLLIER et al. (1973), O'HARA (1973), THURBERG et al. (1973), THORP and LAKE (1974), WEIS (1976), CALABRESE et al. (1977) and THURBERG et al. (in press).

This study reports the lethal concentrations of cadmium and chromium to juvenile blue crabs, Callinectes sapidus, in acute toxicity tests at three different salinities. This economically important crustacean ranges throughout estuaries from fresh water to marine salinities, and may be subject to heavy metal pollution in industrial areas.

MATERIALS AND METHODS

Juvenile blue crabs were collected during Nov. 1973 through Non. 1974 from the northern parts of Sabine Lake, Texas. Mean carapace width of experimental crabs was 1.5 cm, range 1.2 to 2.2 cm. The 24, 48, 72 and 96-hr LC_{50} was determined for exposure to cadmium and chromium at salinities of 1, 15, and 35 ppt. Artificial seawater was prepared at 70 ppt using "Instant Ocean", and adjusted by dilution with aged tapwater. Test crabs were acclimated at salinity intervals of 1, 5, 12, 20, 28 and 35 ppt as appropriate, for a minimum of one day at each interval before transferal to the next interval. Crabs were acclimated for at least one week before testing, and all were tested within 10 days of collection. During acclimation they were fed chopped shrimp and fish daily, but were not fed for two days before nor during testing. The water was changed every two days prior to testing, but the solutions were not changed during the tests. Test solutions of reagent grade cadmium as cadmium chloride ($CdCl_2$. 2 1/2 H_2O) and chromium as potassium dichromate ($K_2Cr_2O_7$) were prepared at a range of concentrations indicated by preliminary toxicity tests. Chromium exists in several oxidation states, of which the trivalent and hexavalent are toxic. Hexavalent chromium is thermodynamically stable in seawater, whereas trivalent chromium is rapidly adsorbed to sediment

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particles (CUTSHALL 1966).

Crabs were tested in groups of 10, along with a control for each group, in 10-liter rectangular polyethylene pans compartmentalized by the addition of small perforated polystyrene containers each 5 cm radius by 4.5 cm deep. Individuals were isolated in these containers to prevent cannibalism. The pans were partially filled with three liters of test solution and were aerated throughout the exposure period. Duplicate tests were performed at each concentration and salinity. The pH ranged from 7.1 to 8.2 for the cadmium solutions and from 6.5 to 7.9 for the chromium solutions. Temperature ranged from 20 to 22 C.

Each test was monitored for 96 hr. Crabs were checked daily for survival, and dead individuals were removed. From the percent survival at each concentration the LC_{50} values were determined according to the method of LITCHFIELD and WILCOXIN (1949) in which concentrations are plotted against percent survival on logarithmic-probability paper and the points connected by a straight line, which intersects the 50% survival line at the LC_{50} concentration. Ninety-five percent confidence limits were also computed for each value.

RESULTS

Cadmium as expected was much more toxic than chromium at all salinities (Figs. 1, 2, Table 1). The 96-h LC_{50} at 1 ppt was 0.32 ppm cadmium and 34.2 ppm chromium. Toxicity of both metals decreased with increasing salinity, although there was little difference between the 48-h LC_{50} values for chromium at 15 and 35 ppt. The 96-h LC_{50} at 35 ppt was 11.6 ppm cadmium and 98 ppm chromium.

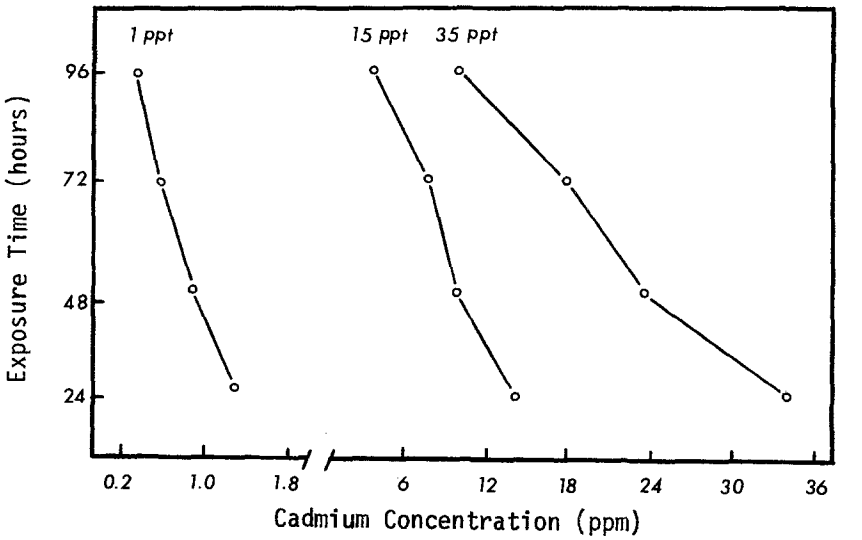

Figure 1. Effect of salinity on cadmium toxicity.

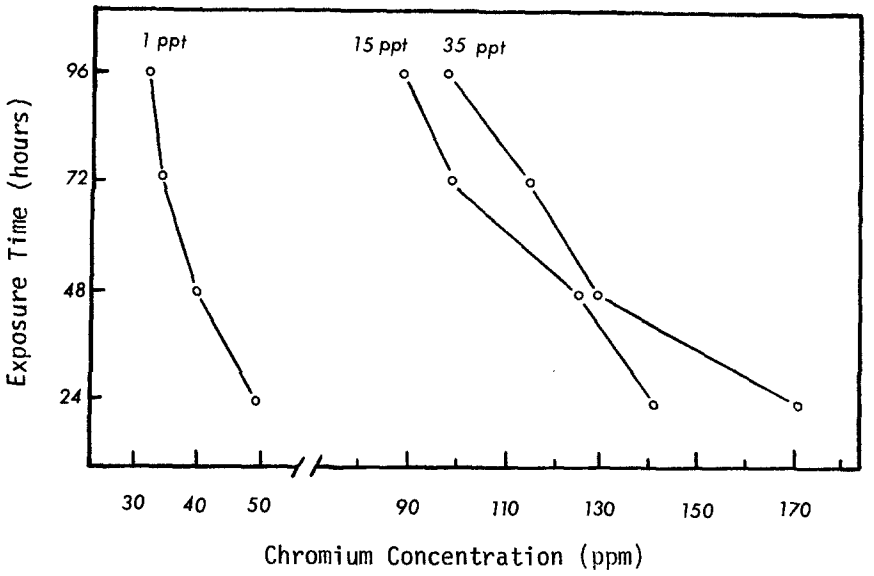

Figure 2. Effect of salinity on chromium toxicity.

TABLE 1

LC_{50} values and 95% confidence limits for cadmium and chromium at various exposure times in three different salinities

Time hours	Salinity ppt	LC_{50} ppm Cd	95% Conf. Limits	LC_{50} ppm Cr	95% Conf. Limits
24	1	1.25	1.02-1.53	48	45-51
	15	13.8	11.3 -16.9	142	131-153
	35	34.1	27.7 -41.9	171	162-181
48	1	0.90	0.66-1.23	39	35-44
	15	9.4	7.8 -11.3	126	110-145
	35	23.8	19.9 -28.5	130	121-140
72	1	0.65	0.50-0.85	36	33-40
	15	7.4	6.7 -8.8	98	90-108
	35	17.8	13.9 -22.9	114	103-127
96	1	0.32	0.20-0.51	34	31-37
	15	4.7	3.5 -6.3	89	80-99
	35	11.6	9.0 -15.0	98	90-106

DISCUSSION

Juvenile blue crabs were considerably more sensitive to cadmium than fiddler crabs (O'HARA 1973), but less sensitive than two species of shrimp (Crangon and Palaemonetes) and the hermit crab Pagurus (EISLER 1971). The 96-h LC_{50} of 4.7 ppm cadmium for Callinectes sapidus at 15 ppt agrees closely with the 4.1 ppm obtained by EISLER (1971) for the crab Carcinus maenas at 20 ppt. The 96-h LC_{50} of 98 ppm chromium for C. sapidus is comparable to the 50 ppm "toxic value" reported by RAYMONT and SHIELDS (1963) in preliminary tests during three days on Carcinus maenas in seawater. Chromium was less toxic to blue crabs than to the brackish water clam, Rangia cuneata at comparable salinities (OLSEN and HARREL 1973).

CALABRESE et al. (1977) recently pointed out that early life history stages of marine animals tend to be less sensitive to cadmium than to other heavy metals, but that this order of toxicity is reversed in adults, with cadmium producing more severe effects. Tests on larval and adult blue crabs would be of interest to determine if their cadmium sensitivity differs from that reported here for juveniles.

One limitation of acute toxicity tests is that they fail to evaluate sublethal effects of long-term exposure to lower concentrations of a pollutant. For example, the 96-h TL_m (at 30 ppt, 20 C) was 37.0 ppm cadmium for the fiddler crab, Uca pugilator (O'HARA 1973), and although cadmium concentrations of 1.0 mg/L (ppm) were not toxic during 28 days, exposure to only 0.1 mg/L retarded limb regeneration (WEIS 1976). It has been shown that cadmium depresses the level of gill-tissue oxygen consumption in crabs (COLLIER et al. 1973, THURBERG et al. 1973). Two general effects of sublethal metal exposure on crustaceans and finfish are induction of enzymes and loss of ligand sensitivity (CALABRESE et al. 1977).

Exposure to acutely toxic ionic concentrations may be somewhat unrealistic in that such concentrations are unlikely even in polluted natural waters, and primary biological uptake routes are probably related more to food and feeding than to direct uptake from the water (Benayoun et al. 1974, PHELPS et al. 1975). Chromium, however, does not appear to be accumulated at higher trophic levels in food webs (PHELPS et al. 1975).

Despite the heavy industrialization surrounding Sabine Lake and vicinity, neither cadmium nor chromium levels appear to be significantly elevated in Sabine Lake macrofauna. SCRUDATO et al. (1976) reported 0.4 ppm cadmium (wet weight) in blue crabs and up to 4.0 ppm in oysters (Crassostrea virginica), while chromium concentrations in oysters were <0.1 ppm. HOROWITZ and PRESLEY (1977) found average values of 0.16 ppm cadmium (dry weight of flesh) and 2.1 ppm chromium in brown shrimp (Penaeus aztecus) from the south Texas outer continental shelf. Permissible

discharge levels into inland and coastal waters have been established by the Texas Water Quality Board (1970) at 0.02 mg/L cadmium and 5.0 mg/L chromium.

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