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The Influence of Temperature and Salinity on the Toxicity of Hexavalent Chromium to the Grass Shrimp *Palaemonetes Pugio* (Holthuis)

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INTRODUCTION

Interactions between organisms and pollutants are influenced by changes in natural environmental variables that can alter the physiological condition of the subject or the physico-chemical characteristics of the system (BRYAN, 1971). In dynamic environments such as bays and estuaries, some knowledge of the ways in which the variables affect the organism-pollutant interactions is necessary for the most effective management of these coastal areas. The purpose of this study was to indicate the influence of temperature and salinity on the capacity of hexavalent chromium (potassium chromate) to cause physiological damage to the grass shrimp Palaemonetes pugio as evidenced by static 48-hr acute toxicity bioassays performed in eight different thermosaline combinations (10,15,20,25°C x 10,20 ppt).

Hexavalent chromium most often appears as a water soluble chromate or dichromate, both powerful oxidants that can easily penetrate biologic membranes and irritate cells (MERTZ, 1969). These compounds are extensively manufactured and utilized by a variety of industries; often, they are found in industrial effluents (DUGAN, 1972).

Palaemonetes pugio is an abundant and important member of the food webs of bays and estuaries of our east and gulf coasts (WELSH, 1975). The species represents a large invertebrate group (the Caridea) for which little, if any, information on hexavalent chromium toxicity exists.

MATERIALS AND METHODS

The shrimp were collected by seining the Ulva beds at the mouth of the Shrewsbury River in Sandy Hook Bay, Sandy Hook, New Jersey. They were returned to the laboratory and maintained at 15°C in aquaria containing aerated bay water. Before the bioassays, individuals were drawn randomly from the holding tanks and acclimated in artificial sea water (Rila Marine Mix, Rila

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Products, Teaneck, NJ) to the desired thermosaline combination for three days. Gravid females and individuals less than 2 cm in body length were not used.

The basic bioassay procedures followed were those outlined in Standard Methods (A.P.H.A., 1971). Chromium stocks were prepared by dissolving reagent grade potassium chromate in water of both salinities to a concentration of 1 mg Cr/l. Aliquots of these stocks were combined with artificial sea water to make test solutions of varying chromium concentration.

Ten 20.2-cm diameter glass tissue culture dishes were used for each thermosaline combination. Each dish contained one liter of a test solution and 10 acclimated shrimp. Chromium concentrations were run singly or in groups as needed to establish results and each concentration was 10 to 20 ppm more than the preceeding one. Control dishes containing 10 shrimp were run for each thermosaline combination. The dishes were checked regularly and dead animals were removed as they were found. The final mortality data included those shrimp that, after 48 hours of exposure, were either dead or in a moribund condition such that recovery would have been impossible. The characteristics used to identify the moribund condition were: 1) inability to maintain normal dorsal-ventral orientation; 2) failure to respond to physical stimuli; 3) slow or erratic movement of the gill bailers; and 4) an opaque milky-white abdomen rather than the normal transluscent appearance. The 48-hr TL_m (median tolerance limit) values and 95% confidence intervals were calculated using probit analysis according to BLISS (1938).

RESULTS AND DISCUSSION

Table 1 and Figure 1 summarize the results of this study. The data indicate that, for acute exposure, the capacity of hexavalent chromium to cause physiological damage to Palaemonetes pugio is enhanced by increased temperature or decreased salinity as evidenced by the smaller TL_m values. The susceptibility of the shrimp was greatest at 25°C/10 ppt and least at 10°C/20 ppt. The effects of both variables were pronounced, but salinity was more consistent in altering toxicity. The implications are that Palaemonetes pugio is most likely to be adversely affected by hexavalent chromium when the habitat is warm (summer and early autumn, thermal effluents) and dilute (mouths of rivers, periods of heavy rainfall).

Previous studies have given similar results with other organisms. CAIRNS and SCHEIER (1959) studied the toxicity of potassium dichromate to the bluegill, Lepomis macrochirus, at 18°C and 30°C in hard and soft water. The 96-hr TL_m values were highest in hard water at 18°C, next highest in hard water at 30°C, and lowest

TABLE 1.

HEXAVALENT CHROMIUM CONCENTRATIONS (mg Cr/l) AND 95% CONFIDENCE INTERVALS LETHAL TO 50% OF TEST ORGANISMS IN 48 HOURS AT DIFFERENT TEMPERATURES AND SALINITIES

		Temperature(°C)			
		10	15	20	25
Salinity(ppt)	10	81±12	39±6	37±6	21±4
	20	147±16	107±10	78±15	77±6

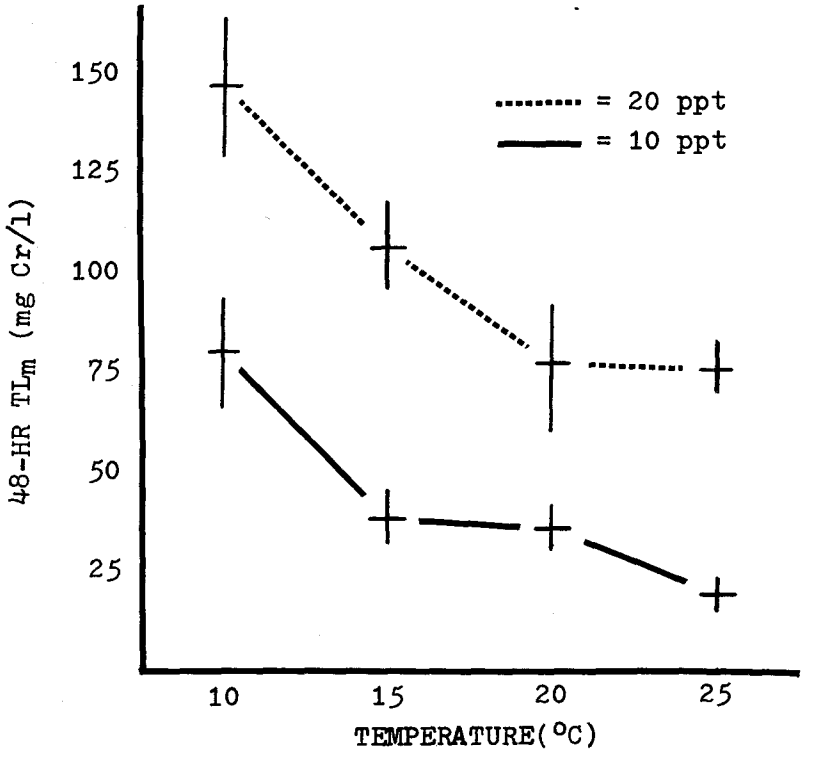

Figure 1. Effect of temperature and salinity upon the toxicity of potassium chromate to Palaemonetes pugio. Vertical lines represent 95% confidence intervals.

in soft water at both temperatures. TRAMA and BENOIT (1960) found that increased hardness and alkalinity of the water increased the 96-hr TL_m values of potassium chromate and potassium dichromate for L. macrochirus. OLSON and HARREL (1973) looked at the effect of salinity on the toxicity of potassium dichromate to Rangia cuneata, an estuarine pelecypod, and found that the 24-, 48-, and 96-hr TL_m values all increased as the salinity rose from 1 to 5.5 to 22 ppt. Apparently, water temperature and the concentration of other dissolved solids are important factors influencing the impact of hexavalent chromium on at least several different organisms.

This study indicates that single-value chromium exposure standards for estuarine organisms like Palaemonetes pugio are insufficient unless they are derived from the most deleterious combination of variables that the organisms are likely to encounter. Although the acute chromium concentrations used here were higher than might be expected to occur, chronic exposure to lower concentrations could cause sublethal disturbances such as decreased reproductive potential or increased susceptibility to predation or environmental extremes. The development of sublethal effects would probably also be influenced by changes in temperature and salinity.

REFERENCES

AMER. PUB. HEALTH ASS.: Standard methods for the examination of water and waste water. 13th ed. Washington, D. C., Amer. Pub. Health Ass. 1971.

BLISS, C. I.: Quart. J. Pharm. Pharmacol. 11, 192 (1938).

BRYAN, G. W.: Proc. Roy. Soc. London B177, 389 (1971).

CAIRNS, J., JR., and A. SCHEIER: Trans. N. E. Wildl. Conf. 10, 86 (1959).

DUGAN, P. R.: Biochemical ecology of water pollution. New York, Plenum Press. 1972.

MERTZ, W.: Physiol. Rev. 49, 163 (1969).

OLSON, K. R., and R. C. HARREL: Contrib. Mar. Sci., Univ. Texas 17, 9 (1973).

TRAMA, F. B., and R. J. BENOIT: J. Wat. Poll. Cont. Fed. 32, 868 (1960).

WELSH, B. L.: Ecology 56, 513 (1975).