EFFECTS OF HEXAVALENT CHROMIUM ON DEVELOPMENT OF CRABS, RHITHROPANOEUS HARRISII AND CALLINECTES SAPIDUS

C. G. BOOKHOUT
Dept of Zoology, Duke University, Durham, NC 27706, U.S.A.

R. J. MONROE
Dept of Statistics, North Carolina State University, Raleigh, NC 27607, U.S.A.

R. B. FORWARD, Jr. and J. D. COSTLOW, Jr.
Duke University Marine Laboratory, Beaufort, NC 28516, U.S.A.

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Abstract. Survival of Rhithropanopeus harrisii larvae from hatching to first crab stage occurred in Na$_2$CrO$_4$ concentrations from 1.1 to 29.1 ppm. Estimated LC50 for complete zoeal development was 17.8 ppm Na$_2$CrO$_4$ and it was 13.7 ppm for development to first crab stage. A concentration of 1.1 ppm Na$_2$CrO$_4$ was nontoxic, while Na$_2$CrO$_4$ concentrations of 7.2 and 14.5 ppm were sublethal and concentrations of 29.1 to 58.1 ppm were acutely toxic. Low concentrations of Na$_2$CrO$_4$ caused an increase in swimming speed and high concentrations caused a decline.

Survival of Callinectes sapidus larvae occurred in Na$_2$CrO$_4$ concentrations from 1.1 to 4.7 ppm. The LC50 for complete zoeal development was estimated to be 2.9 ppm Na$_2$CrO$_4$ and the LC50 for development to first crab stage was estimated to be 1.0 ppm Na$_2$CrO$_4$.

The total Cr in sodium chromate is 32% by weight (Tacey, 1981), hence, the total Cr concentrations tested were 32% of the Cr salts given above.

Statistical analyses of the data on survival, duration and mortality of larvae are presented.

1. Introduction

One of the trace metals in drilling fluids which may have a detrimental environmental effect is Cr. The toxicity of Cr to marine organisms will vary with valence state, pH, and oxidation states. Hexavalent Cr (Cr$^{+6}$) is stable in seawater. It often appears as a soluble chromate or dichromate, a powerful oxidant which can readily penetrate biological membranes and irritate cells (Mertz, 1969). Hexavalent Cr, as chromic oxide, chromate or dichromate, reacts with organic matter in acidic solution, leading to the trivalent form (Cr$^{+3}$). The trivalent form is associated chiefly with particulate matter, such as clay, which suggests by analogy, that organic particulate matter may also reduce and bind the hexavalent form in solution (NRC, 1974; Curl et al., 1965). Hexavalent Cr is much more toxic to organisms than trivalent Cr, in part because Cr$^{+6}$ is water soluble and Cr$^{+3}$ has a very low solubility in seawater.

Chromium is contributed to drilling fluids chiefly as the lignosulfonate which is added in greater amounts as mud weight is increased (Hrudey and Eng, 1979). Ferrochrome lignosulfonate, brand name 'Q-Broxin', and chrome lignosulfonate are common additives to drilling fluids which contribute to Cr enrichment. Liss et al. (1980) reported that
Q-Broxin included a metallic composition of 7% Na, 3% Cr, 1% Fe, and 0.3% Ca W/W. Initially, Q-Broxin contains hexavalent chromate salts, but at temperatures between 120 to 175 °C Cr\(^6\) is converted to the Cr\(^3\). The thinning property of Q-Broxin can be restored at temperatures between 120 and 175 °C by adding more Cr\(^6\). Above 175 °C no more Cr\(^6\) will restore lost thinning ability.

Knox (1978) has suggested that after drilling fluids are discharged into the ocean, Cr and associated material are released slowly in soluble form from clay particles into the water. Once freed from clay particles, Cr\(^3\) through slow oxidation may revert to Cr\(^6\) as Cranston and Murray (1980) discovered in their experiments. In other research, Cr\(^3\) oxidation rates of 3\% in 30 days occurred at 22 to 26 °C, and at 35 °C and 45 °C the same extent of oxidation occurred at 10 days and less than 3 days, respectively. Fukai and Vas (1969) reported Cr\(^3\) oxidation rates of 7\% Cr\(^6\) in one week. Most investigators assume that all of the Cr in drilling fluids is trivalent even though analyses were not made to determine the valence. Other investigators, as Liss et al. (1980), apparently are not certain that all of the Cr in drilling fluids is trivalent. Personal communication with several investigators concerning the presence of Cr\(^6\) in discharged drilling fluids brought forth such comments as 'doubtful', 'under certain conditions', 'might vary from 5 to 20\% depending upon input into drilling fluid and time samples was taken'.

It may be concluded from the above discussion that the possibility exists that under certain conditions both Cr\(^3\) and Cr\(^6\) may be discharged. Most of the discharge would undoubtedly include Cr\(^3\) and not be too bioavailable for planktonic organisms. If Cr\(^6\) were included in the discharge, it would be more bioavailable than Cr\(^3\) and in the course of time would bioaccumulate if assimilated.

This investigation was undertaken to determine the concentrations of Cr\(^6\), Na\(_2\)CrO\(_4\), which are nontoxic, sublethal and acutely toxic to the complete larval development of the mud crab, *Rhithropanopeus harrisii*, and the blue crab, *Callinectes sapidus*.

2. Materials and Methods

2.1. Source of Animals

Adult *R. harrisii* which furnished larvae for series RhI to RhVI used in sodium chromate experiments were collected near Morehead City and Havelock, N.C., while they were in the refractory period during the fall of 1980 and winter of 1981. They were placed in an artificial habitat in the laboratory where the temperature of the water was 30 °C and there was 14 hr light and 10 hr darkness per day. When the crabs became ovigerous, they were isolated in separate large finger bowls (19.4 cm diam) and maintained in a constant temperature cabinets at 25 °C under a light regime of 12 hr light and 12 hr darkness until hatching occurred. The largest and most healthy hatches were selected for the experiments. Larvae for RhI and RhII hatched on January 20, 1981. The other dates of hatching were February 17, 1981 for RhIII, February 23, 1981 for RhIV, March 8, 1981 for RhV and March 19, 1981 for RhVI.