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TOXICITY STUDIES OF CHROMIUM

Chromium is a toxic metal widely used in industry and released in wastewaters. Although there have been few environmental studies of the metal, we know that levels in world ocean waters are very low (0.05 to 0.5 ppb) and that concentrations in Pacific Ocean sediments are considerably higher (4 to 93 ppm). Total chromium concentrations in undiluted municipal wastewaters discharged in southern California average about 500 ppb. Thus after an immediate dilution of 100:1 upon discharge, the waters around an outfall might contain as much as 5.0 ppb chromium. There is very little information available on the effects of chromium on marine organisms. Nevertheless, the California State emission control standards call for a much lower chromium concentration in discharged wastes: According to the standards, the effluent must not contain more than 5.0 ppb more than 50% of the time.

The uncertainties concerning chromium toxicity encouraged us to initiate a study similar to those being conducted on copper, nickel, and cadmium in other laboratories around the country: We want to identify the range of chromium concentrations that do not elicit biological response or inhibit reproduction and survival of marine organisms. We have reviewed available published information and have conducted a number of chromium toxicity experiments on marine animals; several of the experiments are discussed here.

METHODS

We performed 10 and 14 day static toxicity experiments, using concentrations of hexavalent chromium (as potassium dichromate) ranging from 0.06 to 50 ppm. The organisms tested were juvenile nereid polychaetes (*Neanthes arenaceodentata*) supplied from cultures maintained by Dr. Donald J. Reish of California State University, Long Beach. These animals naturally inhabit and live in mucous tubes.

Twenty animals per concentration were used in each experiment; each animal was placed in 100 ml of toxicant solution in a 500 ml Erlenmeyer flask. A series of flasks for control specimens and for water quality monitoring were also set up. During the experiments, the test organisms were examined daily for several responses, including death, inability to build and inhabit mucous tubes, and abnormal reflex acts. In addition, toxicant concentration and water quality (dissolved oxygen, pH, and nitrites) were monitored several times during the experiments. Water temperature was recorded daily. The animals can normally go several weeks without food, but we fed the test organisms in the 14 day experiment on the 10th day to observe feeding behavior.

RESULTS

Control specimens demonstrated that laboratory conditions did not inhibit natural responses of the worms. They were able to survive and maintain mucous tubes on the sides and bottom of the glass flasks. However, water quality did change somewhat even though the ratio of gm body weight per liter of water was well below that recommended. Figure 1 shows the toxicity curves for survival and tube building based on LC50 and EC501 estimates from both experiments. The 2 , 3 , and 4 day ECso estimates for tube building from the two experiments were similar, but the 1 day (24 hour) estimates were not. In the 14 day experiment, a threshold appeared in the curves after about the 10th day; for tube building, the threshold concentration was about 0.08 ppm chromium. The threshold response for acute toxicity appeared to occur at concentrations between 0.S and 1.0 ppm.

Levels of chromium in the flasks appeared to remain constant during both experiments.

In the 14 day experiment, actual values were initially within 1 to 13 percent of desired values, with the greatest variation occurring in the flasks with the lowest chromium concentration. After 9 days, values remained within 4 percent of the initial values. However, it seemed that the introduction of food contaminated the control and generally reduced chromium concentrations in the flasks.

Although dissolved oxygen was at or near saturation in all flasks during the polychaete experiment, other water quality parameters did change. Increases in nitrites and pH (measured on the first and last days) were apparent at the end of the experiment. Chromium itself did not reduce the pH at the range of concentrations used.

The possibility that water quality will change during long term static experiments must always be considered. By measuring the chromium in some of the flasks during our experiments, we know that desired levels were closely approximated and did not change until food was added. The accumulation of toxic metabolic products from the polychaetes (ammonia, nitrites, etc.) may have accelerated the toxic responses to chromium. On the other hand, if the food added during the last days of the 14 day experiment adsorbed some of the dissolved chromium, our estimate of the concentrations causing mortality or behavioral changes is too high.

Results from other experiments illustrate the necessity of frequently monitoring water concentrations of an introduced metal in toxicity experiments. For example, we monitored the chromium concentration in an unoccupied 160 liter aquarium with a sand and carbon filter. The initial chromium value was 2 ppm; during the first 7 1/2 days, the concentration fluctuated about this value, with a standard deviation of approximately 2 percent. Then coastal mussels were introduced into the tank. The mussels spawned, and the chromium concentrations decreased by 5 percent in a few hours; during the next 5 days, the values fell by another 15 percent.

DISCUSSION

There have been many studies of toxic effects of hexavalent chromium salts (chromates and dichromates) and trivalent and divalent oxides, sulfates, and chlorides on freshwater organisms, but data on chromium toxicity in marine organisms are much fewer. Both marine and freshwater studies indicate that hexavalent chromium is considerably more toxic and less likely to exist than other forms, including the less soluble trivalent form that dominates total chromium in sewage wastewaters. Thus our experiments have produced decidedly conservative data.

The acute toxicity of hexavalent chromium for both marine and freshwater organisms appears to range between 1 and 330 ppm (actual values vary greatly with species, salinity, pH, alkalinity, and temperature). Our results an acute toxicity value of about 1 ppm chromium for *Neanthes arenaceodentata* indicate this to be a particularly sensitive species.

There is less information available on sublethal effects of chromium (i.e., in the range of O.OO1 to 1 ppm). Past studies have shown that marine and freshwater organisms concentrate radioactive labeled chromium compounds from very dilute solutions (0.001 to 0.1 ppm), but no effects (such as death or alterations in behavior or reproduction) have been noted.

The results of our preliminary experiments indicate that more effort directed toward defining both acute and sublethal effects of chromium will provide information pertinent to chromium emission standards and the health of coastal biota. Technical problems encountered during these initial experiments are being assessed in order to define better guidelines for future experiments. Problems of immediate concern are: 1) utilizing optimum adaptations of both static and flowthrough systems; 2) monitoring water quality in both systems 3) determining effects of chromium speciation.

Experiments to determine the effect of low concentrations of chromium on reproduction and to investigate accumulation of chromium in Neanthes are now underway, with some improvements in monitoring and controlling water quality. When completed in about five months, these data will be submitted for publication.

We greatly appreciate the efforts of Dr. Donald J. Reish and Mr. Phil Oshida, California State University at Long Beach, for their collaboration and interest in this work. Jean Wright and Cindy Smith assisted in setting up and monitoring the experiments.

FIGURES

Figure 1.

Toxicity curves for survival and tube building in *Neanthes arenaceodentata* in chromium at concentrations of 0.06 to 50 ppm