Copper Residue in Rainbow Trout

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ABSTRACT

Copper residue in rainbow trout (*Salmo gairdneri* Richardson) was not related to length of exposure time or concentration of algaecide after treatment with two copper compounds. Copper sulfate pentahydrate and copper triethanolamine (Cutrine) were administered by a continuous delivery drip system and the copper residue in fish was analyzed by atomic absorption spectroscopy.

INTRODUCTION

The addition of copper salts and their effects on organisms in the aquatic environment were reviewed in detail by McKee and Wolf (1). Copper sulfate pentahydrate ($CuSO_4$-$5H_2O$) has been widely used but its effectiveness as an algaecide is often reduced by high alkalinity and hardness in the waters. However, these water quality factors have little effect on copper triethanolamine (Cutrine), which behaves much more stable than copper sulfate pentahydrate in aqueous solution. Most of the previous works (2,4,5,7) on the effect of copper toxicity to fish were to determine the lethal dosage or median tolerance limits. Although levels of copper accumulation hazardous to human consumption have been reported in marine shellfish (1,3), little is known about the nature of copper accumulation in freshwater fishes.

The purpose of the present study was to determine the copper residue in fish bodies using Cutrine and copper sulfate pentahydrate as copper sources.

MATERIALS AND METHODS

During the summer of 1970, rainbow trout (*Salmo gairdneri* Richardson) were exposed to 0.125, 0.250, 0.375, 0.500, 0.625, 0.750, 1.000, 2.000, 4.000, 6.000 and 8.000 ppmw of copper for 24, 48, 72 and 96 hr in order to determine the amount of copper which might be accumulated in their bodies. The fish were hatched in January of 1970, and kept in nursery tanks until they were used in the summer. All of the fish used were between 30 and 45 mm long and weighed from 2.2 to 4.2 g. The test fish were not fed for 24 hr prior to stocking and throughout the experiment.

Twenty fish were exposed to each copper concentration. At the intervals of 24, 48, 72, and 96 hr, five fish were removed from each concentration and rinsed in distilled water. These fish were immediately packed in plastic bags and were stored in a freezer for copper determination. This constituted one replication. In all, four replications, or 80 fish per concentration, were analyzed.

The two copper sources used in this study were copper sulfate pentahydrate and Cutrine. All treatments were based on the copper percentage of these compounds. Copper sulfate pentahydrate and cutrine containing 25.5% and 7.1% of copper by weight respectively were dissolved in double distilled water as stock solution.

Four epoxy coated nursery tanks measuring 3.6 m by 0.6 m by 0.45 m were used in the experiment. Spring water with a temperature of 12 ± 2 C was used to reduce the variation in water quality. Chemical characteristics of the water are presented in Table 1. A continuous delivery "drip system" (6) was used to administer the copper stock solution into the tanks. Water samples were analyzed for copper periodically in order to check the desired concentrations in the tanks.

Two fish, selected at random, of each frozen sample were weighed after thawing at room temperature and blotted dry with filter papers. Those samples were blended and ashed at 500 C in the muffle furnace for 12 hr. Each ash sample was then transferred and dissolved in 5 ml of 4 M nitric acid. Copper concentrations were subsequently determined using a Jarrel Ash Atomic Absorption Spectrophotometer at the wave length 3246 Å. Fuel (H_2) and oxidant (O_2) ratio was 10:10 according to the manual pre-

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TABLE 1. CHEMICAL ANALYSIS OF TEST WATER

Measurement	Concentration[a]
CO_2	7.0
Dissolved oxygen	11.0
pH	8.0
Alkalinity	273.6
Total hardness	290.7
Total dissolved salts	280.0

[a]All measurements in ppmw except pH.

pared by the manufacturer. The concentrations of copper residue are reported in mg copper per kg fresh weight of fish (ppmw).

RESULTS AND DISCUSSION

The average value of copper in control fish was 2.8 ppmw as compared to 3.9 and 4.5 in the fish treated with Cutrine and copper sulfate pentahydrate, respectively (Table 2). However, there is no relation between copper content of the fish treated and the length of their exposure time to copper.

Fish treated with copper sulfate pentahydrate at concentrations above 1.000 ppmw of copper showed acute toxicity during a 24 hr exposure. Salmonids were often reported for their sensitivity to copper in soft water. Sprague (4,5) showed that the salmon (*Salmo salar* L.) avoided copper at the concentrations as low as 4 to 5 ppbw in water of low hardness (14.8 ppmw $CaCO_3$). The resistance to copper toxicity has also been shown in water with high alkalinity and low temperature. Measurement for alkalinity and hardness in this study indicated that the spring water was favorable for fish to survive in relatively high copper concentrations.

TABLE 2. COPPER CONCENTRATION (PPMW) IN FISH

Concentration	Gross Accumulation		Net Accumulation[a]	
	Cutrine	$CuSO_4 \cdot 5H_2O$	Cutrine	$CuSO_4 \cdot 5H_2O$
0 (control	2.8	2.8	0	0
0.125	....	2.8	....	0
0.250	4.5	2.8	1.7	0
0.375	4.3	3.9	1.5	1.1
0.500	3.2	3.8	0.4	1.0
0.625	3.9	....	1.1	....
0.750	4.0	....	1.2	....
1.000	1.9	2.8	−0.9	0
2.000	2.0	2.6	−0.8	−0.2
4.000	10.3	5.4	7.5	2.6
6.000	2.0	....	−0.8	....
8.000	2.8	12.4	....	9.6
Average	3.9	4.5	1.1	1.7

[a]Differences between controls and treated fish.

Despite the wide range of copper concentrations that was applied in the experiment, the fish did not accumulate copper proportionatlly. Perhaps a physiological mechanism is adopted to control the absorption of copper or to excrete excess copper to prevent its accumulation in tissues.

The copper content in the rainbow trout is lower than that reported for oysters (*Crassostrea virginica* Gmelin). Roosenburg (3) reported that the copper residues of oysters near electric generating stations were often above 100 ppmw which is the recommended maximum allowable copper level for human consumption.

CONCLUSIONS

From the data considered, the following conclusions can be drawn. First, there is no apparent relationship between the length of exposure and the amount of copper residue in the fish. Second, there is no relationship between the concentrations of copper to which the fish was exposed and the amount of copper residue which is detected in the fish. Finally, there is no obvious difference in the amount of copper residue between the two copper sources.

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