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Acute Toxicity of Iodine to Channel Catfish (*Ictalurus punctatus*)

Michael J. LeValley

Division of Biology, Kansas State University, Manhattan, KS 66506

As part of the screening process for a fish parasiticide (a tri-iodinated ion exchange resin), the acute toxicity of diatomic iodine (I_2) to channel catfish (Ictalurus punctatus) was determined. The general use of chlorine, another halogen, as a disinfectant and antifouling chemical has led to many studies documenting its severe toxicity to fish at low concentrations (ZILLICH 1972, BRUNGS 1973). The only known information concerning the toxicity of iodine to fish is reported by GOZLAN (1968) who found that 8.0 mg/liter was lethal to a species of mullet (Mugil sp.). The exposure period was not reported.

This research was undertaken to determine, in a preliminary fashion, the toxicity of iodine in a static exposure to channel catfish.

MATERIALS AND METHODS

Channel catfish fingerlings were obtained from the Kansas Fish and Game Commission and held in 150-liter stainless steel flow-through troughs at a temperature of 18 C. The test fish were 60 to 100 mm total length and 2.0 to 7.3 g total weight.

Stock solutions of toxicant were made as needed by dissolving 1 g of iodine crystals (analytical reagent grade) in 1 liter of distilled water at 60 C. This yielded typical stock concentrations of 0.72 to 1.00 mg/milliliter. Stock preparations were wrapped in aluminum foil and stored in the dark to limit photodecomposition. Solutions were routinely checked before use by analyzing for iodine according to the method of PALIN (1967) modified by the HACH CHEMICAL COMPANY (1973).

Preliminary bioassays of iodine against channel catfish were carried out in 4-liter glass aquaria to delimit a range of concentrations giving between 10 and 90 percent mortality. Final bioassays were run in 60-liter glass aquaria for intervals of 1, 2, 10, and 24 hours. The test water was dechlorinated tap water with total alkalinity of 62.7 to 72.0 mg/liter, pH of 7.2 to 7.6, and temperature of 20.2 to 22.4 C (Table 1). Dissolved oxygen,

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temperature, pH, and total alkalinity were measured initially and at the end of each assay.

TABLE 1

Range of initial and final water chemistry parameters observed in experimental and control aquaria during exposures of free iodine to channel catfish

Parameter	1 hour	2 hour	10 hour	24 hour
Dissolved oxygen (mg/liter)				
Initial	8.2- 8.8	7.5- 8.3	7.9- 8.5	8.2- 9.0
Final	8.0- 8.5	7.5- 8.2	8.0- 8.5	8.1- 9.0
Temperature C				
Initial	21.0-21.7	20.5-21.3	21.6-22.4	20.3-21.0
Final	21.1-21.7	20.5-21.3	21.6-22.4	20.3-21.2
Total Alkalinity (mg/liter)				
Initial	67.0-72.0	64.0-68.0	65.0-67.0	65.0-72.0
Final	65.0-69.0	63.0-70.0	64.6-68.9	63.4-70.6
pH				
Initial	7.4- 7.5	7.2- 7.4	7.3- 7.4	7.2- 7.3
Final	7.3- 7.4	7.3- 7.4	7.3- 7.4	7.2- 7.4

Fish loading rates did not exceed 1 g/liter of water. Channel catfish were acclimated for at least two hours prior to introduction of the iodine. Prior to acclimation, the test water was analyzed for the presence of chlorine using the Hach Chemical Company's DPD method. All test fish were starved for 72 hours prior to and during any bioassay to lessen metabolites in solution. At the end of each test, viable fish were placed in 30-liter glass recovery aquaria and observed for 48 hours. A negative control, consisting of the same test water, conditions, and organisms, but containing no iodine, was maintained concurrently with each exposure. Generally, iodine concentrations in the 1-hour assays remained constant. In all other tests iodine concentration was monitored at one hour intervals and extra chemical was introduced to adjust for loss of iodine, presumably due to photodecomposition and organic matter. These periodic adjustments undoubtedly introduced some imprecision into the experiment.

Percent mortality versus iodine concentration was plotted on log-probability paper. Median lethal concentration (LC) 50 values (with 95 percent confidence intervals) were determined using the graphical techniques of LITCHFIELD AND WILCOXON (1949). Their method was also used to transform no and 100 percent mortality data, to test for goodness of fit for the lines drawn, and to determine the slope function of the lines.

RESULTS AND DISCUSSION

The toxicity of iodine to channel catfish varied with the exposure period. Concentrations as low as 0.72 mg/liter resulted in 100 percent mortality during the 24-hour exposure period (Table 2). A much higher concentration (7.22 mg/liter) was necessary for complete mortality during a short exposure period (1 hour). Concentrations causing no mortality ranged from 0.10 to 1.50 mg/liter for the 24- and 1-hour tests, respectively. These concentrations are within the very-toxic to toxic categories of toxicity as described by SPRAGUE (1973). No-mortality levels were roughly one-half of the LC50 value. Mortality was absent in the control groups and water chemistry parameters were similar in both experimental and control groups over the exposure period (Table 1).

TABLE 2

The acute toxicity of iodine to channel catfish.

Duration of Test (hours)	No. Tested	No Mortality (mg/liter)	100% Mortality (mg/liter)	LC50 (mg/liter) (95% confidence interval)	Slope Function
1	60	1.50	7.22	3.00 (2.22-4.05)	2.21
2	40	1.20	4.30	2.10 (1.63-2.71)	1.76
10	48	0.50	1.52	0.98 (0.89-1.07)	1.42
24	50	0.10	0.72	0.44 (0.40-0.49)	1.44

Inactivity, loss of equilibrium, color fading, "piping," massive gill damage, and hemorrhaging at the base of the fins were symptomatic of iodine poisoning. The hemorrhaging reaction at the base of the fins was also described by ZILLICH (1972) during exposures of chlorinated effluents to fathead minnows. In all toxicity tests channel catfish never recovered after loss of equilibrium and most fish died within 30 minutes of equilibrium loss. Gill damage consisted of severe hemorrhaging and "clubbing" in the gill filaments, sloughing of gill epithelium and production of large amounts of mucous. These symptoms are similar to those attributed to chlorine (CAIRNS et al. 1975).

The toxicity of iodine to channel catfish appears to be similar to the toxicity of another halogen, chlorine. Over exposure periods of 1 and 24 hours, MARKINGS and BILLS (1977) found the toxicity of chlorine to be 1.38 and 0.156 mg/liter, respectively. These concentrations are lower than those for iodine but within the same order of magnitude (Table 2).

Free residual chlorine (FRC) is believed to kill fish by causing gill damage and eventual asphyxiation (CAIRNS et al. 1975). The components of free residual chlorine, hypochlorous acid (HOCl) and hypochlorite ion (OCl^-), are both toxic, but HOCl is about four times as toxic as OCl^- (MATTICE et al. 1981). The percent of FRC present as HOCl depends on pH because of the influence of hydrogen ion concentration on the dissociation of HOCl. Similarly, diatomic iodine dissociates to form hypoiodous acid (HIO) and hydrogen (H^+) and iodide (I^-) ions. At a pH of 7, HIO and I_2 are present in approximately equal parts, but at a pH of 8, there is approximately 88 percent HIO and 12 percent I_2 (BLACK et al. 1965, WYSS & STRANDKOV 1945). These observations suggest that HIO may be responsible for the damage seen in the gill filaments of the bioassay fish.

It is concluded that iodine is very toxic to channel catfish and approaches the toxic range of chlorine. In addition, mortality is apparently due to asphyxiation caused, at least initially, by severe gill damage.

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