Bull. Environ. Contam. Toxicol. (1993) 51:564–567

Environmental Contamination and Toxicology

Toxicity of Diquat Pulse Exposure to Tropical Freshwater Shrimp (*Caridina nilotica*, Atyidae)

S. D. Kevan[1] and R. G. Pearson[2]

[1]Enviroquest Ltd., 352 River Rd., Cambridge, Ontario, N3C 2B7, Canada and
[2]Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, Queensland, 4811, Australia

Diquat (1,1'-ethylene-2,2'-dipyridylium ion) is an herbicide that is used for controlling nuisance aquatic weeds (e.g., water hyacinth) in tropical freshwater lakes and rivers (Q.R.L.P.B. 1989). Although diquat is highly water-soluble and is absorbed by the weeds, the rate at which it breaks down in the water depends upon other modifying factors such as the presence of mud or suspended silt, the amount of sunlight, and the flow of water (CCREM 1987). The variability in the persistence of diquat in sediments is known to be highly dependent on the organic content (Naqvi *et al.* 1980, CCREM 1987).

The toxic effects of diquat on freshwater fish and invertebrates have been studied extensively under various exposure conditions (Summers 1980). However, little information exists on the short-term effects of diquat exposure on aquatic organisms found in tropical rivers. The purpose of this research is to determine the toxicity of diquat to *Caridina nilotica*, a representative and common crustacean which inhabits freshwater areas associated with water hyacinth (Williams 1989).

MATERIALS AND METHODS

Adult shrimp (*C. nilotica*) were collected along the banks of the Ross River (Townsville, Queensland). In the laboratory (James Cook University) the shrimp were acclimated in de-chlorinated water (Table 1) at a temperature of 24°C, in 100-L aquaria for 72 hr prior to bioassays.

Nominal test solutions of 62.5, 125, 250 and 500 mg diquat formulation (active constituent)/L (Active constituent: 200 g/L Diquat Dibromide Monohydrate; ICI Australia Operations Pty., Ltd., Melbourne, Victoria, Australia) were prepared by direct addition to 4.5 L of de-chlorinated laboratory water (James Cook University) (Table 1) in 5-L tanks. Water samples and temperature were taken at the beginning of each test. Analysis of diquat concentrations in water, pH, and conductivity were carried out by the Department of Primary Industries, Agricultural Chemistry Branch (Brisbane, Queensland, Australia). Diquat concentrations were analyzed by the ultraviolet method (Yuen *et al.* 1967) and tested by Carlstrom's (1968).

For each test, shrimp averaging 1.5 cm (± 0.2 S.D.; N = 38) in length, were randomly distributed into 5 tanks with diquat concentrations ranging from 0 to 500 mg/L. For test 1, 10 shrimp were used per concentration, and for each of tests 2 and 3, 15 shrimp were used. Mortality was recorded each hour, for 2 hours. At the end of each 2-hr test shrimp

Send reprint requests to S.D. Kevan at the above address

TABLE 1. Characteristics of a single sample of de-chlorinated dilution water. The values are given as mg/L with the exception of pH (unitless), conductivity (mS/cm), and turbidity (NTU's).

Parameter	Concentration
pH	7.6
Conductivity	.200
Turbidity	1.6
Total suspended solids	<0.5
Sodium	15.5
Potassium	2.8
Calcium	9.2
Magnesium	2.4
Sulphate	18.0
Chloride	29.8
Bicarbonate	2.9
Total nitrogen	9.1
Nitrate	2.1
Nitrite	0.004
Ammonia	0.014
Total phosphate	0.22
Orthophosphate	0.22

were transferred to clean water for 15 min. Shrimp that did not respond to gentle prodding after being transferred into diquat-free water were considered dead. The mean (± S.D.) temperature for all three tests was 23.4 ± 0.5°C.

The pulse exposure LC50 (PE-LC50) values were calculated by the Trimmed Spearman-Karber method (Hamilton *et al.* 1977). Comparisons of PE-LC50 values were analyzed by the standard error of the difference (SED) (Sprague and Fogels 1977). The level of rejection was greater than or equal to 1.

RESULTS AND DISCUSSION

For the control water the pH and the conductivity was 6.8 and 87 uS/cm respectively. Diquat was not detected (detection limit is 0.02 mg/kg/litre H_2O) and no mortality was recorded in the control for all three tests.

The PE-LC50s and their 95% confidence intervals for tests 1, 2, and 3 were 241.7 (178.6-327.2), 200.4 (154.8-259.3) and 185.9 (146.4-236.0) mg/L respectively. The SED calculated for test 1 vs. 2 (0.81), test 1 vs. 3 (0.76) and test 2 vs. 3 (0.88) were not significantly different. Therefore the three tests were combined and a PE-LC50 was calculated. The combined 2-hr PE-LC50 was 213.4 (179.4-254.0) mg/L.

Previous studies on short-term exposures of crustacea to diquat reported a 26-hr IC50 (median immobilization concentration) for *Daphnia magna* to be 7.1 mg/L (Crosby and Tucker 1966), and for copepods and *Hyalella azteca* the 48-hr LC50s were reported to be 19 and 3.4 mg/L respectively (Naqvi *et al.* 1980, Williams *et al.* 1984). In our study we have shown that a 2-hr pulse exposure to diquat concentrations of $\geq$ 213.4 mg/L was acutely toxic to the tropical freshwater shrimp *C. nilotica*. Although the 2-hr PE-LC50

TABLE 2. Measured diquat concentrations (mg/L), pH, conductivity, and percent (%) shrimp mortality for tests 1, 2 and 3.

	Diquat (mg/L)	pH	Conductivity (mS/cm)	Percent (%) Mortality
Test 1				
	59.8	6.3	0.200	10
	136	6.9	0.330	20
	275	6.6	0.550	30
	318	6.6	0.625	90
Test 2				
	54.4	6.8	0.200	20
	113	6.8	0.290	13
	265	6.7	0.535	67
	389	6.6	0.725	87
Test 3				
	57.7	7.0	0.200	7
	122	6.8	0.300	13
	231	6.7	0.480	73
	468	6.6	0.725	93

may be greater than recommended concentrations (80 mg/L diquat/1000 m^2 of plants (excluding wetting agents)) for single field applications (Q.R.L.P.B. 1989), it is conceivable that higher concentrations of diquat could occur in the field where saturation of diquat to densely infested areas of plants is necessary.

Acknowledgments. Financial support for this project was provided by the Townsville-Thuringowa Water Board, Queensland, Australia, and Enviroquest, Ltd., Cambridge, Ontario, Canada. We would like to thank Dr. Bruce Simpson of the Queensland Department of Primary Industries, and Adam Goldrick, Australian Centre for Tropical Freshwater Research, for their assistance with water quality analysis. Voucher specimens of *C. nilotica* have been deposited at the British Museum of Natural History.

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Received October 24, 1991; accepted March 24, 1993.