J. Biosci., Vol. 3, Number 4, December 1981, pp. 457–462. © Printed in India.

Toxicity of carbaryl and 1-naphthol to four species of freshwater fish

K. S. TILAK, D. MOHANARANGA RAO, A. PRIYAMVADA DEVI and A. S. MURTY*

Department of Zoology, Nagarjuna University, Nagarjunanagar 522 510

MS received 3 April 1980; revised 22 September 1981

Abstract. The toxicity of the carbamate insecticide carbaryl (Seven®) and its metabolite, 1-naphthol, to four species of fish was studied. The calculated 96 h LC 50 values of carbaryl for *Catla catla* (Ham.), *Anabas testudineus* (Bloch), *Mystus cavasius* (Ham.) and *Mystus vittatus* (Bloch) are 6.4, 5.5, 4.6 and 2.4 ppm respectively and that of 1-naphthol are 4.3,3, 0.33 and 1.1 ppm respectively. The degradation product of the insecticide was found to be more toxic than the parent compound, to all the four species studied.

Keywords. Pesticide toxicity; carbaryl; 1-naphthol; freshwater fish.

Introduction

Carbaryl (n-naphthyl, 1-methyl carbamate), is a carbamate pesticide that is being used widely to control a variety of pests of different crops. In India it is being extensively used against the pests of cotton, tobacco, paddy, vegetable crops and the like. It is considered to be environmentally safe because of its shorter persistence and lower mammalian toxicity (Brown, 1978) and hence is more acceptable than the 'environmentally hazardous' organochlorine and organophosphate pesticides. 1-Naphthol, the main degradation product of carbaryl, especially in the aquatic environment (Karimen *et al.* 1967), is supposed to be non-toxic to the nontarget organisms. However, the toxicity of 1-naphthol to the aquatic organisms does not seem to have been adequately tested and in the few studies on the toxicity to aquatic organisms of carbaryl and its degradation product the latter has been reported to be more toxic (Stewart *et al.*, 1967. Butler *et al.*, 1968 and Tilak *et al.*, 1980). Earlier, we reported that 1-naphthol was more toxic than the parent compound to two size groups of the carp. *Labeo rohita* (Ham.) (Tilak *et al.,* 1980).

The present investigation was undertaken to study the toxicity of carbaryl and 1-naphthol to the following economically important Indian fish: *Catla catla* (Ham.), *Anabas testudineus* (Bloch), *Mystus cavasius* (Ham.) and *M. vittatus* (Bloch).

* Present address: Biologische Anstalt Helgoland, Litoral Station, List/Sylt, 2282 LIST (Sylt), West Germany.

Materials and methods

The source of the fish, their size and average weight are shown in table 1. The fish were acclimatised to the laboratory conditions in well aerated, unchlorinated tap water at 28° ±2°C. During the period of acclimatization and experimentation, the fish were not fed. If the number of deaths exceeded 5% in any batch of fish during acclimatization, that batch was discarded. To test the toxicity of the two compounds, tests were conducted employing continuous flow systems, using large reservoirs and gradient flow as recommended in the report of the "Committee on methods of toxicity tests with aquatic organism (Anon, 1975)."

Table 1. Length, weight and source of fish used in the toxicity tests.

Species	Size range (cm)	Average wt. (g)	Source
Catla catla	1-2.5	0.3	Hatchery at Manchikalpudi, Guntur Dt., Andhra Pradesh[a]
Mystus vittatus	4.5-6	3.5	Guntur channel near Nambur, Andhra Pradesh
M. cavasius	5-6.5	4	—do—
Anabas testudineus	4-5.5	8	Kolleru lake, Andhra Pradesh

[a] The carps were being bred by injecting pituitary hormones.

Extraction of the pesticide containing water with methylene chloride at hourly intervals after the addition of the pesticide, followed by colorimetric analysis (Benson and Finnocchiaro, 1965) showed that for six hours following the addition of the pesticide, there was no detectable reduction in the concentration of the toxicant in the water in large glass reservoirs (24 to 30 L capacity). Hence, test solutions of desired concentrations were prepared in glass reservoirs, once in five hours and were let into the test containers through thin walled polyethylene tubes (vide recommendations of the above cited committee). The flow rate was adjusted with regulators so that four litres of water passed through the test containers in one hour. Standard solutions of the toxicants (100 mg/ml and 10 mg/ml) were prepared in acetone. The control fish received an equal quantity of acetone. The precautions suggested by the above cited committee in washing the containers, choice of the test fish, loading etc., were carefully followed. The length of the longest fish in any batch did not exceed one and a half times that of the smallest fish.

The hydrological conditions of the test medium are shown in table 2. The water used in the experiments was clear, unchlorinated ground water pumped from a deep well in the university campus.

Table 2. Chemical analysis of water used for toxicity tests.

Turbidity	8.5 silica units
Electrical conductivity at 28°C	816 micromhos/cm
pH	8.4
Total solids	680 mg/L
Total hardness	152 mg/L
Carbonate hardness as Ca CO_3	152 mg/L
noncorbonate hardness as Ca CO_3	nil
Alkalinity as Ca CO_3:	
Phenolphthalein alkalinity	10 mg/L
Methyl orange alkalinity	320 mg/L
Chloride as Cl^-	5.4 mg/L
Fluoride as F^-	2.6 mg/L
Iron	nil
Manganese	nil
Phosphate as PO_4^{3-}	nil
Sulphate as $BaSO_4$	148 mg/L
Nitrate as N	1 mg/L
Free chlorine	nil
Dissolved oxygen	8-10 ppm
O_2 absorbed in 4 hours for $KMnO_4$	0.6 mg/L

The sample of water is clear, colourless and odourless.

Different tissues of randomly selected control fish were extracted with methylene chloride. The extract was concentrated and analysed by both coiourimetry and thin layer chromatography. The fish were found to be free from residues of carbaryl (detection limit, 0.1 ppm).

Pilot experiments were conducted to choose five test concentrations that resulted in mortality in the range of 10-90%. For each concentration, ten fish were tested and the experiment was repeated thrice. Finney's unweighted regression method of probit analysis (Finney 1971) as recommended by Roberts and Boyce (1972), was followed to calculate the 96-hour LC 50 values. The difference between the observed and calculated values was tested for significance using the Chi-square test.

Results

There were no deaths in the control fish during the period of experimentation. The 96-hour LC 50 values of carbaryl and 1-naphthol, with their 95% confidence limits are shown in table 3. The regression equations for the four species of fish whose tolerance to carbaryl and 1-naphthol was tested, are as follows: Y=4.83X–8.25 for carbaryl and Y=6.61X–11.37 for 1-naphthol for *A. testudineus,* Y=2.6X–1.18 for carbaryl and Y=3.09X–1.34 for 1-naphthol for *M. cavasius,* Y= 18.4X–46.6 for carbaryl and Y=25.36X–61.79 for 1-naphthol for *C. catla.* The calculated LC 50 values of Carbaryl for *C. catla, A. testudineus, M. cavasius* and *M. vittatus* are 6.4, 5.5,4.6 and 2.4 ppm respectively and of 1-naphthol, 4.3,0.33 and 1.1 ppm respectively. Thus, for all the four species of fish, 1-naphthol was more toxic than the parent compound.

Table 3. Calculated 96-hour LC 50 values and their 95% confidence limits.

Species	Compound tested	LC 50 (ppm)	95% confidence limits	Calculated a^2 value
Catla catla	1-naphthol	4.3	4.2-4.4	4.03[a] (at 3 degrees of freedom)
	carbaryl	6.4	5-8.2	1.66[a] (at 4 degrees of freedom)
Mystus vittatus	1-naphthol	1.1	0.9-1.4	1.91[a] (at 3 d.f.)
	carbaryl	2.4	1.8-3.1	2.23[a] (at 3 d.f.)
M. cavasius	1-naphthol	0.33	0.25-0.4	0.36[a] (at 5 d.f.)
	carbaryl	4.6	4.1-5.2	5.52[a] (at 3 d.f.)
Anabas testutus	1-naphthol	3	2.7-3.4	2.65[a] (at 4 d.f.)
	carbaryl	5.5	4.8-6.3	1.91[a] (at 5 d.f.)

[a] not significant at 5% level. d.f., degrees of freedom.

Discussion

Although carbaryl and 1-naphthol were not as toxic to fish as many organochlorine and organophosphate pesticides, their toxicity was high enough to make them environmental hazards, if for any reason (rain immeditely after spraying, accidental spillage etc.) contamination of the aquatic environment should occur.

The four species of fish whose susceptibility to carbaryl and 1-naphthol was tested, belonged to three different families. It is surprising to note that the carp, *C. catla* which is supposed to be a very sensitive fish, incapable of withstanding environmental stress, is the least sensitive of the four, to both carbaryl and 1-naphthol. It may also be noted that in the case of the carp only fingerlings were used, whereas in the case of the other three adults were used. *Catla* of the same size as that of the other three species will have a higher LC 50 value (as it is well known that larger size groups have a higher tolerance to toxicants), in which case the disparity in the tolerance of the carp and the other species is very striking. A similar instance of greater sensitivity of air-breathing fish to endosulfan was reported by Rao (1979).

Between the two species of *Mystus,* carbaryl was relatively more toxic to *M. vittatus* than *M. cavasius,* whereas the reverse was true with 1-naphthol. Moreover, for *C. catla, A. testudineus* and M. *vittatus* 1-naphthol was more toic than carbaryl by a factor of one and half to two times, whereas for *M. vittatus* 1-naphthol was about 14 times more toxic than carbaryl.

Acknowledgements

The authors thank the authorities of University Grants Commission and the Council of Scientific and Industrial Research, New Delhi for financial assistance. The supply of technical grade carbaryl by The Union Carbide of India is gratefully acknowledged.

References

Anonymous (1975) *Committee on methods of toxicity tests with fish, macroinvertebrates and amphibians.* Environmental Protection Agency, Oregon, 61 pp.

Benson, B. W. And Finnocchiaro, J. M. (1965) *J. Assoc. Offic. Anal. Chem.,* **48,** 676.

Brown, A. W. A. (1978) *Ecology of pesticides* (New York: John Wiley and Sons) p. 525.

Butler, J. A., Milleman, R. E. and Stewart, N. E. (1968) *J. Fish. Res. Bd. Can.,* **25,** 1621.

Finney, D. J. (1971) *Probit analysis* (Cambridge: University Press) p. 333.

Karinen, J. F., Lamberton, J. G., Stewart, N. E. and Terriere, L. C. (1967) *J. Agric. Food Chem.,* **15,** 148.

Rao, D. M. R. (1979) *Studies on the persistence of endosulfan in the environment and its effect on fresh-waterfish,* Ph.D. thesis submitted to Nagarjuna University, p. 204.

Roberts, M. and Boyce, C. B. C. (1972) in *Methods in Microbiology,* 7A, 3d. J. R. Norris and D. W. Ribbons, (New York: Academic Press) p. 479.

Stewart, N. E., Millerman, R. E. and Breese, W. P. (1967) *Trans. Am. Fish. Soc.,* **96,** 25.

Tilak, K. S., Rao, D. M. R., Priyamvada Devi, A. and Murty, A. S. (1980) *Indian J. Exp. Biol.,* **18,** 75.