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Variation in Toxicity of Malathion to Air and Water-Breathing Teleosts

H. M. Dutta,[1] J. S. Datta Munshi,[2] P. K. Roy,[2] N. K. Singh,[2] and C. R. Richmonds[3]

[1]Department of Biological Sciences, Kent State University, Kent, Ohio 44242, USA; [2]Post Graduate Department of Zoology, Bhagalpur University, Bhagalpur, India, and [3]Case Western Reserve University, Cleveland, Ohio 44106, USA

Malathion belongs to the widely used group of organophosphorus insecticides. In the mid 1960s there was a shift in insecticide use from the organochlorines to the relatively less stable and rapidly biodegradable organophosphate and carbamate classes (Murphy 1980). Many chemicals of these classes have become environmental contaminants in India (Verma et al. 1979). In India Malathion is one of the insecticides largely used to control mosquitoes and other insects. Its wide use provides many occassions for its entry into aquatic environments. The presence of this chemical in the aquatic environment would adversely affect many non-target species such as fish.

Many researchers (Chowdhary et al., 1981; Verma et al., 1984; Yadav and Singh, 1986; Richmonds and Dutta, 1989) have studied the toxicity of malathion to different species of fish. LC 50 values (Table 1) even for the same species of fish differ from one report to another report. These variations depend upon a number of factors: a) species peculiarities (size, age, sex, physiological state, starvation, emaciation, parasitic infection, mode of breathing), b) ecological peculiarities (temperature, pH, DO, CO_2, hardness of water, rate of flow) and c) pesticide specialities (rate of absorption, technical grade (tg) or commercial grade (cg), rate of degeneration).

The purpose of the present study is to estimate the 24-hr, 48-hr, and 96-hr LC 50 values of malathion to an air-breathing teleost fish <u>Heteropneustes</u> <u>fossilis</u> and to provide a possible explanation for the variations in the LC 50 values between air and water-breathing fishes. <u>Heteropneustes</u> <u>fossilis</u> is a facultative air-breathing fish inhabiting the swamps, pools and ponds of India. These bodies of water are deficient in oxygen content. These fish possess a pair of posterior diverticula from the branchial chambers in the form of respiratory air-sacs. LC 50 or the median tolerance limit (TLm) is the concentration in which 50 percent of the population, tested for a specific period of exposure died. LC 50 data are useful for the calculation of application factor (AP), maximum allowable toxicant

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Send reprint requests to H. Dutta at the above address

Table 1. LC 50 values for Malathion to different fish species.

Fish Species	Malathion Used	LC 50 Value (mg/L) 24 hr	48 hr	96 hr	References
Water-breathing					
Cyprinus carpio	Cg	6.31	5.76	5.15	Verma *et al* (1984)
	Cg	-	-	3.15	Arora *et al* (1971)
Cirrhinus mrigala	Tg	-	5.397	-	Roy & Munshi (1987)
	Cg	-	1.321	-	Roy & Munchi (1987)
	Cg	4.11	4.02	3.18	Verma *et al* (1984)
Labeo rohita	Cg	-	-	5.05	Arora *et al* (1971)
	Cg	1.85	1.46	2.05	Verma *et al* (1984)
Mystus vittatus	Cg	2.81	2.45	2.00	Verma *et al* (1984)
Puntius stigma	Cg	10.25	9.56	8.91	Verma *et al* (1984)
Puntius sophore	Cg	8.15	7.92	7.45	Verma *et al* (1984)
Air-breathing					
Anabas testudineus	Tg	28	-	11.8	Jagdeesh Chandran and Sahai (1989)
Clarias batrachus	Cg	20.41	18.00	16.10	Verma *et al* (1984)
Channa punctatus	Cg	14.48	14.17	13.62	Verma *et al* (1984)
Channa gachua	Cg	16.90	16.42	13.95	Verma *et al* (1984)
Heteropneustes fossilis	Cg	18.49	17.18	15.00	Verma *et al* (1984)
	Cg	-	-	5.00	Yadav & Singh (1986)
	Tg	-	-	12.40	Chowdhary *et al* (1981)
	Cg	16.28	14.53	11.80	Present Study

Cg = commercial grade
Tg = technical grade

concentration (MATC) and for producing a toxicity curve (APHA et al., 1975).

MATRIALS AND METHODS

Live specimens of *H. fossilis* (weight 15.0 - 20.0 g) were seined from ponds of North Bihar and kept in the laboratory aquaria. The water of the aquarium was aerated continuously. Fish were acclimated for 2 weeks and fed chopped goat liver. Feeding was stopped 24 hr before malathion exposure. The average values for the water quality data for the water from the holding and exposure tanks were as follows: temperature 29^{0}C, pH 7.35, DO 7.5 mg/L, CO_2 4 mg/L, alkalinity 115 mg/L as $CaCO_3$, hardness 140 mg/L as $CaCO_3$.

Commercial grade malathion containing 50% of active ingredients (Northern Minerals Ltd., Haryane, India) was used in this study. A test solution with the desired concentration of the pesticide was prepared from a previously made stock solution of the pesticide. Bioassay tests were carried out in large plexiglass aquaria using the renewal method. Test water was renewed after every 24 hr. Trial runs were made to delineate the probable concentration range. Ten fish were used for each trial. Two trials were run for each exposure concentration. The following exposure concentrations were used in this study: 6, 8, 10, 12, 14, 16, 18, 20, 22 mg/L.

The data were analyzed using the probit analysis method (Finney, 1964). The probit mortality was obtained from percent mortality. The data for probit mortality were plotted on graph against log concentrations. The concentration producing a 50% mortality and the slope of the probit lines were drawn for 24, 48, and 96 hr of exposure (Fig. 1).

RESULTS AND DISCUSSION

H. fossilis became excited after exposure to different concentrations of malathion and their surfacing frequencies increased for a few minutes. After an hour, they settled at the bottom and gathered in a corner. The color of the body became pale after about 6 hr.

One hundred percent mortality was observed in 22, 18, 16 mg/L at 24, 48, and 96 hr of exposures respectively. LC 50 values calculated by probit analysis were 16.275 mg/L for 24 hr, 14.526 mg/L for 48 hr, and 11.798 mg/L for 96 hr of exposure.

The toxic effects of the organophosphorus compounds result from their ability to severely inhibit the enzyme acetylcholinesterase (O'Brien et al., 1974). This results in the accumulation of acetylcholine at synapses which produce severe physiological disturbances leading to tetanic paralysis and death.

Durations of latent period depend on the nature and concentration of toxicant used and fish species (with other conditions remaining uniform). But in general, organic pesticides have a short latent period, thus the symptoms of poisoning start as soon as the fishes are exposed. Changes in ventilation rate and surfacing frequencies are the general symptoms noticed in the fish after exposure to the pesticide and these activities help the fish to avoid the contact with poison and fight against the stress (Chowdhary et al., 1981; and Roy and Munshi, 1987).

LC 50 values of malathion for H. fossilis in the present study are lower than (Table 1) what was reported by Verma et al., (1984) and Chowdhary et al., (1981). Chowdhary et al., 1981 calculated the LC 50 value of technical grade malathion (95% active ingredient)) and it approximates the present study.

Table 1 gives a comparative idea of LC 50 values of different fish species and a particular species to an organophosphate malathion. In addition to other factors, LC 50 value is dependent upon ecological factors, fish type and the grade of pesticide used (Fig. 2). Air-breathing fish have a higher LC 50 value compared to water-breathing fish. According to Roy and Munshi (1987), technical grade malathion

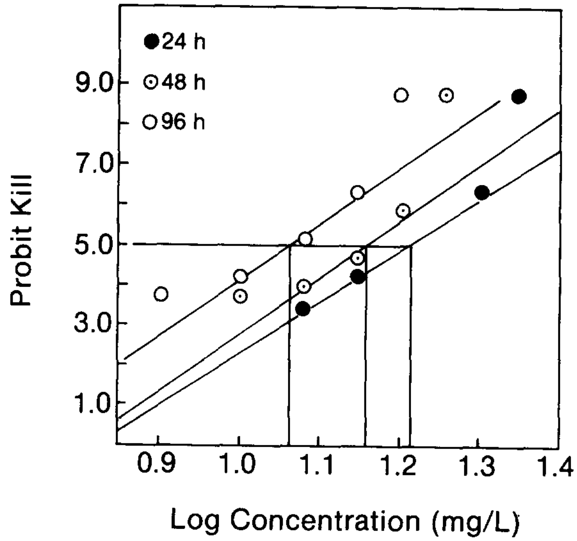

Figure 1. Probit mortality plotted against malathion concentration.

is less toxic than commercial grade malathion. This may be due to other ingredients present as emulsifiers which act as synergists in commercial grade malathion.

Younger fish as compared to older ones have larger respiratory area per unit body weight and a higher metabolic rate. Therefore pollutants are more toxic to younger fish than to older ones. Fish that have water-breathing and air-breathing organs are bimodal with regard to breathing. Bimodal species are noted for their resistance to environmental stresses and aquatic hypoxia (Dehadrai and Tripathi, 1976). These are due to the fact that air-breathing supplements the oxygen requirements in these fishes. Further, they have reduced aquatic respiratory surfaces with a thicker barrier providing a lesser toxicant contact. It is possible that air-breathing renders fish more resistance to toxicants by permitting the reduction of gill ventilation, thereby reducing contact with toxicants at a major site of uptake. For water-breathing fish, toxicity of a wide range of substances increases as dissolved oxygen decreases (Lloyd, 1961). Lloyd (1961) proposed that this increase in toxicity is due to an increased rate of ventilation in hypoxic water. But in bimodal species the hypoxic condition causes a decrease in toxicity. At low oxygen levels these species reduce gill ventilation and rely primarily upon air-breathing (Graham et al., 1978). In the presence of a toxin there was an increased metabolic rate (for a short while) in fishes. The metabolic rate decreased after that. In these fish opercular movement rate decreased, but surfacing frequency increased leading to more air-breathing. Bimodal fishes respond to toxicants by reducing the proportion of oxygen uptake via gills (Kulakkatolickal and Kramer, 1988).

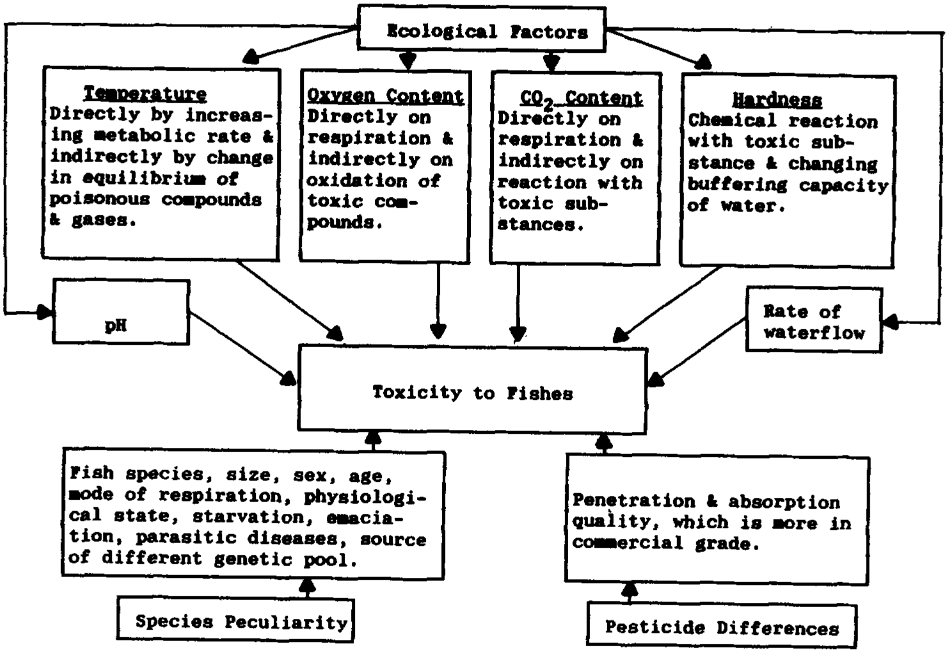

Figure 2. Factors that influence the toxicity of pollutants.

This may explain why air-breathing fish have a reputation for being resistant and difficult to control with the use of pesticides. The capacity to reduce the uptake of noxious substances should be added to the list of other possible advantages of bimodal respiration in fishes.

Susceptibility of fish species to Malathion was as follows:
Clarius bratrachus > Heteropneustes fossilis >Channa gachua > Channa punctatus > Anabas testudineus > Puntius stigma > Puntius sophore > Cyprinus carpio > Labeo rohita > Cirrhinus mrigala > Mystus vittatus.

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