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Environmental Contamination and Toxicology

Toxicity of Selected Insecticides to the Penaeid Prawn, *Metapenaeus monoceros* (Fabricius)

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Hazards of environmental contamination through indiscriminate and widespread use of a variety of pesticides have attracted global attention. These pesticides have been found to be extremely toxic to several aquatic biota including crustaceans (Eisler 1969; Sanders 1969). Paucity of literature on the toxicity of insecticides to penaeid prawns has initiated the present study. In the present study an attempt has been made to investigate the acute toxicity of selected insecticides, which are commonly used in and around this area to penaeid prawn, *Metapenaeus monoceros*. *M. monoceros* selected in the present study is considered to be a sensitive indicator of marine and estuarine pollution (Butler 1966) and also forms one of the important fishery of India.

MATERIALS AND METHODS

Penaeid prawns, *M. monoceros* (Fabricius) were collected from the Buckingham Canal near Kavali seacoast, Andhra Pradesh, India. Only actively swimming intermolt individuals (75 ± 5 mm in length and 2.5 ± 0.2 g weight) were selected from the 'wild' collections for testing. Acclimation and toxicity tests were conducted at constant salinity of 15 ± 1 ppt, pH 7.1 ± 0.2 and temperature of 23 ± 2°C. The prawns were fed ad libitum diet of oil cake powder. Feeding was stopped 24 hr before the beginning of the experiments and no food was given during experiments, to avoid contamination by excrements in the test solution. The media in which prawns were placed was changed periodically at regular intervals. All the troughs were continuously aerated to prevent hypoxia in the medium (Khorram & Knight 1977).

Insecticides like DDT, aldrin, lindane, dieldrin, carbaryl, metasystox, dimethoate, malathion, phospha-

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midon, dichlorvos, methylparathion, phenthoate, sumithion and parathion were used at test chemicals. A stock solution of 1000 ppm (1mg/1mL) and appropriate working concentrations were prepared by dilution with seawater (Table 1). Standard bioassay methods were followed (APHA et al. 1971). Toxicity evaluation studies were conducted in static bioassay system (Doudoroff et al. 1951). Active animals were transferred carefully from acclimatization troughs to the test solutions and bioassays were carried out. Prawns were exposed to different concentrations of selected insecticides. For each concentration 20 prawns were exposed. Mortality was recorded after 96 hr of exposure and dead animals were removed regularly from the test solutions. Each experiment was replicated 5 times to get concurrent values. The test solutions were replaced by fresh solutions of respective concentration of insecticides after every 24 hr to maintain constant concentration of insecticides in test solution. In order to be more accurate in the determination of LC_{50} values, toxicity evaluation was done through probit analysis, graphical method and from cumulative mortality. To determine the LC_{50} through graphical method, the following graphs were drawn (i) a graph between log concentration of pesticide Vs percent mortality (ii) another graph between log concentration of pesticide Vs probit mortality. LC_{50} values were also determined by adopting the following formula of Dragstedt-Behren's method as described by Carpenter (1975).

$$\text{Log } LC_{50} = \text{Log } A + \frac{50-a}{b-a} \times \log 2$$

where

A : Concentration of pesticide, whose concentration is below 50% mortality

a : Per cent mortality observed immediately below 50% mortality

b : Per cent mortality observed immediately above 50% mortality

The data obtained were statistically analysed by the method of probit analysis (Finney 1964) to calculate the LC_{50} values and 95% fudicial limits of mean LC_{50}.

RESULTS AND DISCUSSION

Prawns are active animals, so the symptoms of insecticidal stress are easily detectable. During insecticide exposure, the prawns became restless and showed fast erratic swimming (hyperexcitability). The first indication of insecticide poisoning was irritability, followed by impaired locomotion, restriction of appendage movement and finally death

Table 1. Details of insecticides selected in the present investigation

Insecticide	Chemical name	Purity	Stock solution prepared in	Agency supplied
Aldrin	1,2,3,4,10,10a-hexachloro, 1,4,4a,5,8,8a-hexahydro, 4,4-endo-exo-5,8-dimethano-naphalene	99%	Acetone	M/S Northern Minerals Pvt.Ltd., Gurgaon.
Carbaryl	1-Naphthyl N-methyl carbamate	99%	Acetone	Paushak Ltd., Baroda.
p,p' DDT	Dichloro diphenyl trichloro ethane	50%	Acetone	All India Medical Corporation, India.
Dichlorvos	0,0-dimethyl 2,2-dichlorovinyl phosphate	76%	Distilled water	Hindustan CIBA-GEIGY, Bombay.
Dieldrin	1,2,3,4,10,10-hexachloro-6,7, epoxy-1,4-4a,5,6,7,8a-octa-hydro-1,4-endo-exo-5,8-dime-thanonaphthalene	98%	Acetone	M/S Northern Minerals Pvt.Ltd., Gurgaon.
Dimethoate	0,0-dimethyl 5-(N-methyl carbomyl-methyl) phosphoro-dithioate	30%	Distilled water	Hyderabad Chemicals Supplies Pvt.Ltd., Hyderabad.
Lindane	γ-Hexachlorocyclohexane	99.8%	Acetone	Pesticides India, Udaipur, India.
Malathion	0,0-dimethyl phosphorodithioate diethyl mercaptosuccinate	95%	Acetone	Cynamid India Ltd., Bombay.

Contd..........

Metasystox	Demeton-0-methylsulphoxide-0,0-dimethyl S-2 (Sulphinyl) ethyl phosphorothioate	25%	Distilled water	Bayer India Ltd., Bombay.
Methyl-parathion	0-0,dimethyl,0-p-nitrophenyl thiophosphate	80%	Methoxy ethanol	Bharat Pulverising Mills Pvt.Ltd., Bombay.
Parathion	0,0-dimethyl-p-nitrophenyl phosphorothioate	50%	Methoxy ethanol	Bharat Pulverising Mills Pvt.Ltd., Bombay.
Phenthoate	0,0-dimethyl,S-(ethoxy-carbomyl benzyl) phosphoro-thiolothionate	93%	Acetone	Motilal Pesticides Pvt.Ltd., New Delhi.
Phosphamidon	0,0-dimethyl-0-(1-methyl-2-chloro-2-diethyl-carbomoyl-vinyl) phosphate	92%	Distilled water	Hindustan CIBA-GEIGY, Bombay.
Sumithion	0,0-dimethyl-0-(3-methyl-4-nitrophenyl) phosphorothioate	96%	Ethanol	Rallis India Ltd., Bangalore.

Table 2. Consolidated table showing values of LC_{50} (mg/L) of selected insecticides to penaeid prawn, <u>Metapenaeus monoceros</u>.

Insecticide	Graphical		Dragestedt-Behren's method	Finney's Regression equation method	Average mg/L	% solubility	95% Fudicial limits	
	Sigmoid	Linear					Lower	Upper
p,p'DDT	0.058	0.062	0.069	0.063	0.063	60-65	0.0628	0.0632
Aldrin	0.0320	0.0324	0.0295	0.0353	0.0323	60-65	0.0311	0.0335
Lindane	0.0055	0.0055	0.0058	0.0063	0.00578	60-65	0.0056	0.0059
Dieldrin	0.0385	0.0392	0.0375	0.0424	0.0394	60-65	0.0383	0.0405
Carbaryl	0.0243	0.0246	0.0225	0.0282	0.0249	70-75	0.0237	0.0261
Metasystox	1.17	1.28	1.05	1.66	1.29	70-75	1.1580	1.4220
Dimethoate	2.31	2.47	2.08	2.86	2.43	75-80	2.2658	2.5942
Malathion	1.36	1.52	1.12	1.93	1.4825	60-70	1.3122	1.6528
Phosphamidon	1.08	1.10	1.06	1.32	1.14	100	1.0794	1.2006
Dichlorvos	0.794	0.875	0.898	0.980	0.8868	90-95	0.8485	0.9250
Methylparathion	0.095	0.105	0.064	0.185	0.1123	85-90	0.0865	0.1380
Phenthoate	0.012	0.012	0.017	0.015	0.014	85-90	0.0139	0.0141
Sumithion	0.0021	0.0027	0.0029	0.003	0.0026	75-80	0.0024	0.0028
Parathion	1.12	1.16	1.09	1.35	1.1803	75-80	1.1219	1.2387

occurred. Symptoms of poisoning were somewhat similar for all the insecticides.

It is evident from LC_{50} values (Table 2) that lindane, an organochlorine compound, is more toxic than the other selected insecticides and dimethoate, an organophosphorous insecticide, is least toxic to this species _M. monoceros_. Thus the LC_{50} valures clearly depict that organochlorine and carbamate insecticides are comparatively highly toxic over organophosphorous insecticides. Thus they exhibit toxicity in the order: organochlorines, carbamates, organophosphates. It is obvious from the results that these insecticides are toxic at very low concentrations; even traces of them can cause considerable damage to the prawns. The LC_{50} values of different insecticides for crustaceans like _Gammarus lacustris_, _G. pulex_, crayfish, _Procambarus clarkii_, _P. simulans_, grass shrimp, _Palaemonetes kadiakensis_ and freshwater prawn, _Macrobrachium lamerrei_ (Sanders 1969; Bluzat & Seuge 1979; Muncy & Oliver 1963; Chaiyarach et al. 1975; Shukla & Omkar 1984) were reported. But the comparison of LC_{50} values for _M. monoceros_ with that of other crustacean species provides only a rough indication as to differences in specific tolerance due to variation in a number of factors influencing the bioassay results, like temperature (Macek et al. 1969), species susceptibility (Macek & AcAllister 1970). Thus it is evident that the toxicity differs from species to species (Pickering et al. 1962) and in some cases from place to place, which may be due to differences in bioassay techniques and purity of insecticides as reported by Chambers and Yarbrough (1974). Nebeker and Gaufin (1964) conducted bioassay experiments on the amphipod crustacean, _Gammarus lacustris_, with fourteen insecticides and pointed out that organophosphorous insecticides are generally more toxic than chlorinated compounds. Sanders (1969) and Bluzat and Seuge (1979) also expressed the same views for _G. lacustris_ and _G. pulex_, respectively. In contrast to this view, Omkar and Ramamurthi (1985) reported that organochlorines are relatively more toxic than organophosphates. Eisler (1969) also expressed the same view that "organochlorine insecticides are more toxic to marine fauna than other agricultural, industrial and domestic wastes including organophosphorous insecticides". It is possible that interspecific variation in sensitivity to organophosphorous insecticides is related to the number and types of esterases present. In general the organophosphate insecticides inhibit competitively and irreversibly the action of several enzymes especially cholinesterases, which are chemical mediators of transmission between nerve and effector, resulting in parasympathic, and central nervous system stimulation effects. The bioassays in the present study were conducted under laboratory conditions. The laboratory bioassay provides quickly reliable information about the toxicity of chemicals, although the results differ from field results (Sanders 1969). Bridges (1961) concluded that acute toxicity appears at higher concentrations in the field than in the laboratory. Such laboratory bioassays were also used to study physical, chemical and biological factors influencing the toxicity of different chemicals. The evaluation of toxicity of chemicals to macroinvertebrates like prawn or shrimp has been recommended as one of the methods in water pollution (USEPA 1975). Determination of LC_{50} values is a starting point in studies of toxicological research, since it provides fundamental data for the design of more complex animal studies. Possible explanations for some of these differences in results reported by various investigators may be the different rates of absorption of the insecticides for different concentrations and environmental test conditions, differences in the physiological condition of the test organisms, and differences in models hypothesized and interpretation of results.

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