AQUABYTE

Aquaculture Section
of the Network of Tropical Aquaculture
and Fisheries Professionals (NTAFP)

Editor : M.V. Gupta

The Half-lives of Biological Activity of some Pesticides in Water

Kyaw M.O.

Abstract

In the absence of analytical methods, the half-lives of biological activity of pesticides can be estimated by bioassays. To determine the half-lives of biological acivity of pesticides to fish, static bioassays were conducted in the laboratory with ten different formulations of pesticides using *Labeo rohita* as a bio-indicator. The half-lives of biological activity for ten different pesticides in soft water at pH 7.5 and 27°C, ranged from 4.6 days to 11.8 days. The half-life of biological activity of Sumithion 50% EC was only 4.6 days. In contrast, Dimecron 50% EC degraded very slowly and its half-life of biological activity on *L. rohita* was about 11.8 days. Sumithion 50% EC, Padan 50% SP, EPN 45% EC, Diazinon 40% EC and Diazinon 10 G degraded in less than five to seven days indicating that these pesticides are desirable for rice-fish culture. Contamination by pesticides with long-term residual toxicity in waters may eventually cause high levels of fish mortality.

Introduction

Increased pesticide use in most Asian countries has been reported to have caused the decline in rice-fish culture (Cagauan and Arce 1992). Persistence of pesticides in water is a major consideration in choosing a pesticide for use in rice-fish culture. The number of days which the pesticide would persist in water, is valuable information to prevent fish mortality when stocked in rice fields.

Simple analytical methods to detect and measure very small concentrations of pesticides are unavailable. Without using analytical instrumentation, the persistence or the half-life of biological activity of pesticides in water can be evaluated by a bioassay method using fish as a bio-indicator. The biological activity of a pesticide is its killing power, and the activity generally decreases as a pesticide is deactivated biologically and chemically with time. The half-life of a pesticide's biological activity is the time taken for that activity to be reduced by one-half.

The purpose of this study was to estimate persistence or the half-lives of biological activity of some pesticides in water, so that pesticides that decrease in activity over a short time can be used in rice-fish culture.

Materials and Methods

Bioassays were conducted in the laboratory according to the methods outlined by Lennon and Walker (1964) and APHA (1980) with some modifications to suit our facilities and objectives. *Labeo rohita* was selected as the test fish, ranging from 4.8 cm to 6.8 cm in total length. Ten different pesticides were studied: Sumithion 50% EC (emulsifiable concentrate), Padan 50% SP (soluble powder), EPN 45% EC, Diazinon 40% EC and Diazinon 10 G (granule), Kitazin 48% EC, Furadan 3 G, Kitazin 17 G, Elsan 50% EC and Dimecron 50% EC.

The half-lives of biological activity of the pesticides in water were estimated by using the methods of Marking and Walker (1973). Pesticide solutions were aged over 2, 4, 8 and 16 days, and stronger solutions were prepared for the longer aging periods. As the solutions deactivated to a level of toxicity near the range of tolerance of the test organism, they were bioassayed using the test fish. All the aged solutions and fresh solutions were bioassayed against individuals of the same species to provide reference data.

The results obtained in terms of LC_{50} were used to compute the deactivation index, which was derived by dividing the LC_{50} of an aged solution by the LC_{50} of a fresh solution. The deactivation index was computed for each aging period and the results were plotted on semi-logarithmic coordinates. The deactivation index has a value greater than one if the chemical has deactivated. A value of two indicates that the concentration of an aged solution has diminished by one-half. The aging time required for a deactivation index of two is equivalent to the half-life of biological activity of the toxicant.

Table 1. Toxicity of aged and fresh solutions of ten pesticides to *Labeo rohita* in a 96-hour exposure period at pH 7.5 and 27°C.

Pesticides	Aged Solutions		Fresh solution	Deactivation
	Aging time (days)	LC_{50} (ppm)	LC_{50} (ppm)	Index
Sumithion 50% EC	2	0.44	0.36	1.22
	4	0.62	0.36	1.72
	8	1.19	0.36	3.32
	16	4.25	0.36	12.55
Padan 50% SP	2	0.99	0.77	1.28
	4	1.31	0.77	1.70
	8	2.08	0.77	1.70
	16	5.68	0.77	7.37
EPN 45% EC	2	0.31	0.25	1.24
	4	0.39	0.25	1.56
	8	0.62	0.25	2.48
	16	1.55	0.25	6.2
Diazinon 40% EC	2	0.84	0.68	1.23
	4	1.02	0.68	1.50
	8	1.64	0.68	2.41
	16	3.95	0.68	5.80
Diazinon 10 G	2	3.94	3.4	1.16
	4	5.10	3.4	1.50
	8	7.55	3.4	2.22
	16	17.92	3.4	5.27
Kitazin 48% EC	2	2.16	1.7	1.27
	4	2.62	1.7	1.54
	8	3.40	1.7	2.00
	16	6.81	1.7	4.00
Furadan 3 G	2	0.55	0.47	1.17
	4	0.61	0.47	1.30
	8	0.92	0.47	1.97
	16	1.76	0.47	3.75
Kitazin 17 G	2	2.59	2.2	1.18
	4	2.90	2.2	9.4
	8	3.92	2.2	1.78
	16	7.30	2.2	3.32
Elsan 50% EC	2	0.48	0.41	1.17
	4	0.54	0.41	1.31
	8	0.68	0.41	1.65
	16	1.16	0.41	2.82
Dimecron 50% EC	2	146.52	99.00	1.48
	4	150.48	99.00	1.52
	8	172.26	99.00	1.74
	16	225.72	99.00	2.28

Results and Discussion

The aquarium water had a pH of 7.5, dissolved oxygen 7.0-7.8 ppm, CO_2 2.0-2.4 ppm, total alkalinity 32-35 ppm, total hardness 42-46 ppm and temperature 27°C.

The deactivation indices for ten different formulations of pesticides signify the deactivation occurring over the test periods (Table 1). The half-lives of biological activity for ten different pesticides in soft water ranged from 4.6 days to 11.8 days (Table 2). The results from the bioassay experiments show that Sumithion 50% EC had a half-life of biological activity of only 4.6 days. In contrast, Dimecron 50% EC degraded very slowly and had a half-life of biological activity on *L. rohita* of about 11.8 days. Sumithion 50% EC, Padan 50% SP, EPN 45% EC, Diazinon 40% EC and Diazinon 10 G degraded rapidly whereas Kitazin 48% EC, Furadan 3 G, Kitazin 17 G, Elsan 50% EC and Dimecron 50% EC were more persistent in water owing to their resistance to biochemical degradation. Sumithion 50% EC, Padan 50% SP, EPN 45% EC, Diazinon 40% EC and Diazinon 10 G were degraded in less than five to seven days indicating that these pesticides are desirable for rice-fish culture.

The data from this study, indicate that the granular forms of pesticides are more persistent than emulsifiable pesticides. Applying the pesticides such as Kitazin 48% EC, Furadan 3 G, Kitazin 17 G, Elsan 50% EC and Dimecron 50% EC seven to twelve

Table 2. Half-lives of biological activity of different pesticides on *Labeo rohita* at pH 7.5 and 27°C.

Pesticide	Half-life of biological activity (days)
Sumithion 50% EC	4.6
Padan 50% SP	5.4
EPN 45% EC	6.2
Diazinon 40% EC	6.5
Diazinon 10G	7.0
Kitazin 48% EC	7.6
Furadan 3G	8.5
Kitazin 17G	9.4
Elsan 50% EC	10.8
Dimecron 50% EC	11.8

days before fish are introduced to a rice field would be sufficient for degradation of the pesticides and result in no acute fish mortality.

In previous research on the residual toxicity of some insecticides to fish, DDT was found to degrade slowly, remained toxic to *Clarias batrachus* for about 40 days whereas Malathion remained toxic for only five days (Kyaw Myint Oo 1976). Organochlorines are not desirable for rice-fish culture because of their persistence in the aquatic environment.

Although the experimental results show that these pesticides are toxic to fish for 4.6 days to 11.8 days, repeated applications will prolong the exposure period to fish and may also produce delayed mortality. Therefore, water from a treated field should be prevented from flowing into adjacent fields with fish for at least one or preferably two weeks. Careless use of these pesticides may result in considerable pollution of waters and produce fish mortality.

By using this method, the half-life of biological activity of a toxicant can be determined for various environmental parameters such as pH and temperature. Such information would be invaluable in selecting minimum lethal concentrations of fish toxicants or aquatic herbicides for target species and to avoid affecting non-target species.

Acknowledgement

The author is greatly indebted to U. Than Aye, Deputy General Manager, Crop Protection Division, Myanmar Agricultural Service, Ministry of Agriculture and Irrigation, for his helpful suggestions and comments.

References

APHA. 1980. Standard methods for the examination of water and wastewater. American Public Health Association, Inc., American Water Works Association and Water Pollution Control Federation, New York, 974 p.

Cagauan, A.G. and R.G. Arce. 1992. Overview of pesticide use in rice-fish farming in Southeast Asia, p. 217-233. ***In*** C. R. Dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M. P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Kyaw Myint Oo. 1976. Study on the insecticidal pollution of water by using fish as bioindicators. Burma J. Life Science 4: 22-27

Lennon, R.E. and C.R. Walker. 1964. Investigations in fish control, 1. Laboratories and methods for screening fish-control chemicals. Circular 185. US Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Washington, DC.

Marking, L.L. and C.R. Walker. 1973. Bioassay Techniques and Environmental Chemistry. Ann Arbor Science Publishers Inc., Ann Arbor, MI.

Kyaw M.O. *is from the Department of Zoology, University of Mawlamyine, Myanmar.*