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Acute Toxicity of Two Pesticides Diazinon and Deltamethrin on Gambusia

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Abstract: There is a growing concern over aquatic pollution because of its detrimental effects on biological life including human beings. The goal of the present study was to determine the acute toxicity of diazinon and deltamethrin as potential dangerous organic pesticides to assess mortality effects of these chemicals to the gambusia in the form of LC_{50}. Fish samples (7 fish in each test group) were exposed to different concentrations of diazinon and deltamethrin (between 0-32 ppm for diazinon and 0-0.20 ppm for deltamethrin) for 96 h in 100 L glass aquaria. The very low LC_{50}s obtained for deltamethrin (0.076 ppm) and diazinon (9.710 ppm) indicate that deltamethrin and diazinon are highly toxic to gambusia. Further researches are recommended to study the processes by which these chemicals affect physiology and histology of fish and their accumulation in fish tissues.

Key words: LC_{50} · Gambusia · Diazinon · Deltamethrin · Toxicity

INTRODUCTION

Chemical pesticides with persistent molecules (long half-life periods) pose a threat to aquatic life forms and also to the human population consuming the affected fish [1].

Presence of pesticide in surface waters was reported in Europe and North America since 50 years ago and since then many documents have been proved the toxic effects of these pollutants to aquatic environment [2-5].

Organ phosphorus pesticides (OPs) are widely used in agriculture and the aquatic environment near to fields is under influence of OPs such as diazinon [O,O-diethylO-(2-isopropyl-4-methyl-6-pyrimiinyl) phosphorothioate] [4].

Diazinon is an organ phosphorus pesticide extensively used in agriculture and possesses moderately persistence constitution [6, 7].

The toxicity of diazinon is due to blocking of acetyl cholinesterase (ACHE) activity, which causes harmful impacts on non-target aquatic species close to agricultural fields [7].

The pyrethroids including deltamethrin are largely used as pediculicides and are among the most potent insecticides known [8, 9]. Pyrethroids have been proved to be extremely toxic to fish and some aquatic arthropods, such as shrimps [9-11]. The toxicity of Pyrethroids on amphibians, birds and mammals have been reviewed by Bradbury and Coats [10].

Acute toxicity of a pesticide refers to the chemical's ability to cause damage to an animal from a single exposure, generally of short duration. Many workers have been used the acute toxicity tests of pesticides on fish to acquire rapid estimates of the concentrations that cause direct, irreversible harm to test organisms [12, 13].

The acute toxicity data provide useful information to identify the mode of action of a substance and also help to comparison of dose response among different chemicals. The 96-h LC_{50} tests are conducted to assess the vulnerability and survival potential of organisms to particular toxic chemicals. Chemicals with lower LC_{50} values are more toxic because lower concentrations results 50% of mortality in organisms.

The present study was performed to determine the acute toxicity of diazinon and deltamethrin as potential dangerous organic pesticides to assess mortality effects of these chemicals to the fish gambusia.

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MATERIALS AND METHODS

The selected fish species for the present study was Gambusia. Lethal experiments were conducted using 70 young gambusia. Test chambers were glass aquaria of 100 L. All fish were acclimated for a week in these aquaria before assays with continuous aeration. Water temperature was regulated at 27°C by using aquarium heater. Fish were feed twice per diem with formulated feed and dead fish were immediately removed to avoid possible water deterioration [14].

Nominal concentrations of active ingredient tested were 0, 4, 8, 16 and 32 ppm of commercial dose (60%) for diazinon and 0, 0.01, 0.02, 0.05, 0.10 and 0.20 ppm of commercial dose (2.5%) for deltamethrin were used. 10 groups (5 for diazinon and 5 for deltamethrin) of seven gambusia were exposed for 96h in aerated glass aquaria with 100 L of test medium. During acute toxicity experiment, the water in each aquarium was aerated and the temperature was 27°C. No food was provided to the specimens during the assay and test media was not renewed. Mortality rates were recorded at time 0, 24, 48, 72 and 96 h. Acute toxicity tests carried out according to Hotos and Vlahos [15]. The nominal concentration of diazinon and deltamethrin estimated to result in 50% mortality of Gambusia within 24 h (24-h LC_{50}), 48 h, 72 h and 96 h was attained by probit analysis by Finney's method [16] and using the maximum-likelihood procedure (SPSS 2002, SPSS Inc., Chicago, Illinois, USA). The LC_{50} value is obtained by fitting a regression equation arithmically and also by graphical interpolation by taking logarithms of the diazinon and deltamethrin concentrations versus probit value of percentage mortality.

The 95% confidence limits for LC_{50} are estimated by using the formula:

$$LC_{50}\ (95\%\ CL) = LC_{50} \pm 1.96\ [SE\ (LC_{50})]$$

The SE of LC_{50} is calculated from the formula: $SE(LC50) = 1/b\sqrt{pnw}$

Where: b=the slope of the chemical/probit response (regression) line; p=the number of chemical used, n = the number of animals in each group, w = the average weight of the observations [15]. After the acute toxicity test, the LOEC (Lowest Observed Effect Concentration) and NOEC (No Observed Effect Concentration) were determined for each measured endpoint.

RESULTS

No fish died during the acclimation period before exposure and no control fish died during acute toxicity tests. The mortality of gambusia for diazinon doses 0, 4, 8, 16 and 32 ppm and 0, 0.01, 0.02, 0.05, 0.10 and 0.20 ppm for deltamethrin were examined during the exposure times at 24, 48, 72 and 96 h (Tables 1 & 2). The mortality of gambusia was increased significantly with increasing concentrations from 8 ppm to higher concentrations for diazinon and 0.02 ppm to higher concentrations for deltamethrin.

Median lethal concentrations of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80% and 90% test are presented in Tables 3 and 4. Because mortality (or survival) data are collected for each exposure concentration in a toxicity test at various exposure durations (24, 48, 72, or 96 hours), data can be plotted in other ways; the straight line of best fit is then drawn through the points. These are time–mortality lines. The LT_{50} (median lethal survival time) can be estimated for each concentration.

Toxicity Testing Statistical Endpoints are in tow part: 1- Hypothesis Testing: is there a statistically significant difference between the mean response in the treatments and mean response in control or

Table 1: Cumulative mortality of Gambusia Fish (n=7 each concentration) exposed to acute diazinon

	No. of mortality			
Concentration (ppm)	24h	48h	72h	96h
0.00	0	0	0	0
4	0	0	0	0
8	2	3	3	4
16	2	5	6	6
32	7	7	7	7

Table 2: Cumulative mortality of Gambusia Fish (n=7, each concentration) exposed to acute deltamethrin

	No. of mortality			
Concentration (ppm)	24h	48h	72h	96h
0.00	0	0	0	0
0.01	0	0	0	0
0.02	0	1	2	2
0.05	1	2	2	3
0.10	1	3	4	4
0.20	7	7	7	7

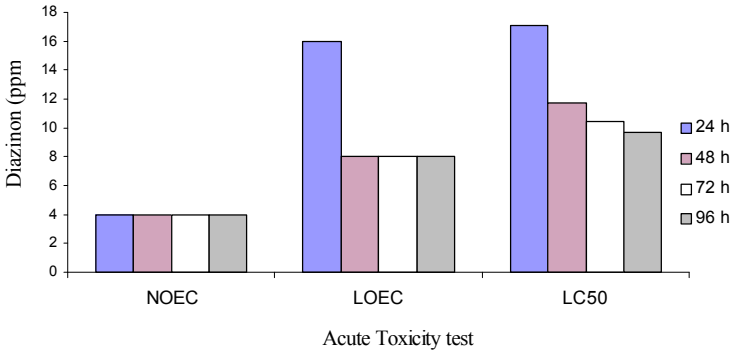

Fig. 1: Acute toxicity testing statistical endpoints in gambusia Fish exposed to crude Diazinon in different times (24h, 48h, 72 h and 96 h respectively)

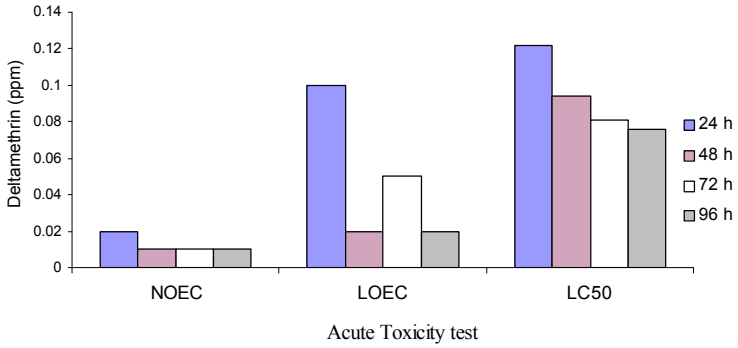

Fig. 2: Acute toxicity testing statistical endpoints in gambusia Fish exposed to Deltamethrin in different times (24h, 48h, 72 h and 96 h respectively)

Table 3: Lethal Concentrations (LC_{1-99}) of diazinon depending on time (24-96h) for Gambusia

	Concentration (ppm) (95 % of confidence limits)			
Point	24h	48h	72h	96h
LC_{10}	7.340	4.794	4.985	4.041
LC_{20}	10.673	7.184	6.867	5.987
LC_{30}	13.077	8.907	8.223	7.390
LC_{40}	15.131	10.380	9.382	8.589
LC_{50}	17.051	11.757	10.466	9.710
LC_{60}	18.971	13.133	11.549	10.831
LC_{70}	21.025	14.606	12.708	12.030
LC_{80}	23.428	16.329	14.065	13.433
LC_{90}	26.762	18.719	15.946	15.380
LC_{99}	34.679	24.396	20.414	20.002

Table 4: Lethal Concentrations (LC_{1-99}) of deltamethrin depending on time (24-96h) for Gambusia

	Concentration (ppm) (95 % of confidence limits)			
Point	24h	48h	72h	96h
LC_{10}	0.068	0.030	0.017	0.011
LC_{20}	0.087	0.052	0.039	0.033
LC_{30}	0.100	0.068	0.055	0.049
LC_{40}	0.112	0.081	0.069	0.063
LC_{50}	0.122	0.094	0.081	0.076
LC_{60}	0.133	0.107	0.094	0.089
LC_{70}	0.145	0.120	0.108	0.103
LC_{80}	0.158	0.136	0.124	0.119
LC_{90}	0.176	0.158	0.146	0.141
LC_{99}	0.221	0.210	0.199	0.194

reference sample. LOEC: Lowest Observed Effect Concentration; NOEC: No Observed Effect Concentration. 2- Point Estimates: what toxicant concentration will cause a specific effect on the test population? LC_{50}: the median Lethal Concentration. Our result for Toxicity Testing Statistical Endpoints is shown in Fig. 2.

DISCUSSION

The results of the present study indicate that both chemicals diazinon and deltamethrin varied in their acute toxicity to gambusia. The toxicity of deltamethrin and diazinon on gambusia increased with increasing concentration and exposure time.

Occurrence of pesticides in high concentrations in agricultural wastewaters and their toxicity to aquatic organisms especially fish species have been reported by many researchers [3, 5, 7]. Contamination of aquatic environment with pesticides via rainfall runoff is very possible [17]. Fishes are sensitive to aquatic contamination and serious concerns remains due to their potential to cause adverse effects on human and wildlife populations. In addition we found that both diazinon and deltamethrin are lethal substrates to gambusia. The 96h LC_{50} was calculated to be 9.710 ppm for diazinon and 0.076 ppm for deltamethrin and here we report deltamethrin to be highly toxic to fish.

The 96h LC_{50} values of diazinon on different fishes reported from tenths to several tens of mg l^{-1} [18, 19]. Value of diazinon 96h LC_{50} was 0.8 mg l^{-1} for guppy (*Poecilia reticulata*) and for zebra fish (*Brachydanio rerio)* was 8 mg l^{-1} [19, 20]. Different factors have been suggested to cause selective toxicity of diazinon on different fishes: different detoxification, absorption and different inhibition of acetyl cholinesterase [19, 21].

Previous studies, indicate the high toxicity of deltamethrin to fish species and our results are in good agreement with these reports. Boateng *et al*. [22] reported that young fish are more susceptible and different species respond unlike to concentrations of chemicals. Mittal *et al.* [23] estimated deltamethrin toxicity to *P. reticulate* to be LC_{50}=0.016 ppm [23]. Viran *et al.,* reported LC_{50} value of deltamethrin in guppies as 5.13 mg/L [9]. Mestres and Mestres [24] found 96-h fish LC_{50} values as follows: *Salmo gairdneri*, 0.39 mg/L; *Cyprinus carpio*, 1.84 mg/L; and *Sarotherodon mossambica*, 3.50 mg/L [24]. LC_{50} value of deltamethrin in Tilapia, *Oreochromis niloticus* as 15.47 ìg/l was reported by Boateng *et al*. [22]. Although deltamethrin is thought to be less toxic in field conditions due to its adsorption to sediments, these data are useful to potential ecosystem risk assessment [9].

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REFERENCES

1. Langston, W.J., 1990. Toxic effects of metals and the incidence of metal pollution in marine ecosystems. In: Firness, R.W., Rainbow, P.S. (Eds.), Heavy Metals in the Marine Environment. CRC Press, Boca Raton, FL, pp: 101-122.
2. Miller, G.G., L.I. Sweet, J.V. Adams, G.M. Omann, D.R. Passino-Reader and P.G. Meier, 2002. In vitro toxicity and interactions of environmental contaminants (Arochlor 1254 and mercury) and immunomodulatory agents (lipopolysaccharide and cortisol) on thymocytes from lake trout (Salvelinus namaycush). Fish Shellfish Immunol., 13: 11-26.
3. Galloway, T. and R. Handy, 2003. Immunotoxicity of organophosphorous pesticides. Ecotoxicology, 12: 345-63.
4. Tinoco-Ojanguren, R. and D.C. Halperin, 1998. Poverty, production and health: inhibition of erythrocyte cholinesterase via occupational exposure to organophosphate insecticides in Chiapas, Mexico. Arch. Environ. Health, 53: 29-35.
5. Capel, P.D., S.J. Larson and T.A. Winterstein, 2001. The behavior of thirty-nine pesticides in surface waters as a function of scale. Hydrol. Process., 15: 1251-1269.
6. Bazrafshan, E.S., A.H. Naseri, M. Mahvi and Shayedhi, 2007. Performance evaluation of electrocoagulation process for diazinon removal from aqueous environments by using iron electrons, Iranian Journal of Environmental Health Science and Engineering, 4: 127-132.
7. Larkin, D.J. and R.S. Tjeerdema, 2000. Fate and effects of diazinon. Rev. Environ. Contam. Toxicol., 166: 49-82.
8. Smith, T.M. and G.W. Stratton, 1986. Effects of synthetic pyrethroid insecticides on nontarget organisms. Res. Rev., 97: 93-119.
9. Viran, R., F.U. Erkoc, H. Polat and O. Kocak, 2003. Investigation of acute toxicity of deltamethrin on guppies (Poecilia reticulata). Ecotoxicology and Environmental Safety, 55: 82-85.
10. Bradbury, S.P. and R. Coats, 1989. Comparative toxicology of the pyrethroid insecticides. Rev. Environ. Contamin. Toxicol., 108: 133-177.
11. Srivastav, A.K., S.K. Srivastava and S.K. Srivastav, 1997. Impact of deltamethrin on serum calcium and inorganic phosphate of freshwater catfish, Heteropneustes fossilis. Bull. Environ. Contam. Toxicol., 59: 841-846.
12. Parrish, P.R., 1995. Acute toxicity tests, In Fundamentals of Aquatic Toxicology: Effects, Environmental Fate and Risk Assessment, 2nd, ed. G.M. Rand. pp. 947±973.Taylor & Francis, Washington DC.

13. Pandey, S., R. Kumar, S. Sharma, N.S. Nagpure, S.K. Srivastava and M.S. Verma, 2005. Acute toxicity bioassays of mercuric chloride and malathion on air-breathing ?sh Channa punctatus (Bloch). Ecotoxicology and Environmental Safety, 61: 114-120
14. Gooley, G.J., F.M. Gavine, W. Dalton, S.S. De Silva, M. Bretherton and M. Samblebe, 2000. Feasibility of aquaculture in dairy manufacturing wastewater to enhance environmental performance and offset costs. Final Report DRDC Project No. MAF001. Marine and Freshwater Resources Institute, Snobs Creek, pp: 84.
15. Hotos, G.N. and N. Vlahos, 1998. Salinity tolerance of Mugil cephalus and Chelon labrosus, Pisces: Mugilidae/fry in experimental conditions. Aquaculture, 167: 329-338.
16. Finney, D.J., 1971. Probit Analysis. Univ. Press, Cambridge, pp: 333.
17. Willis, G.H. and L.L. McDowell, 1982. Review: Pesticides in agricultural runoff and their effects on downstream water quality. Environ. Toxicol. Chem., 1: 267-279.
18. Tsuda, T., M. Kojima, H. Harada, A. Nakajima and S. Aoki, 1997. Acute toxicity, accumulation and excretion of organ phosphorus insecticides and their oxidation products in killifish. Chemosphere, 35: 939-949.
19. Adedeji, O.B., A. Oadedeji, O.K. Adeyemo and S.A. Agbede, 2008. Acute toxicity of diazinon to the African catfish (Clarias gariepinus) African Journal of Biotechnology, 7(5): 651-654.
20. Keizer, J.D., G. Gostino and L. Vittozzi, 1991. The importance of biotransformation in the toxicity of xenobiotics to fish.1.Toxicity and bioaccumulation of diazinon in guppy (Poecilia reticulata) and zebra fish (Brachydanio rerio). Aquat. Toxicol., 21: 239-254.
21. Oh, H.S., S.K. Lee, Y.H. Kim and J.K. Roh, 1991. Mechanism of selective toxicity of diazinon to killifish (Oryzias latipes) and loach (Misgurnus anguillicaudatus). Aquat. Toxicol. Risk Assess., 14: 343-353.
22. Boateng, J.O., F.K. Nunoo, E.H. R. Dankwa and M.H. Ocran, 2006. Acute Toxic Effects of Deltamethrin on Tilapia, Oreochromis niloticus (Linnaeus, 1758). West Africa Journal of Applied Ecology, 9: 1-5.
23. Mittal, P.K., T. Adak and V.P. Sharma, 1994. Comparative toxicity of certain mosquitocidal compounds to larvivorous fish, Poecilia reticulata. Ind. J. Malariol., 31(2): 43-47.
24. Mestres, R. and G. Mestres, 1992. Deltamethrin: uses and environmental safety. Rev. Environ. Contamin. Toxicol., 124: 1-18.