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Acute Toxicity of DDVP (Dichlorvos) on *Daphnia magna* Straus, 1820

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Abstract: In this study *Daphnia magna* was used as test animals. Daphnids were exposured for 96 h to DDVP concentrations ranging from 0.001-0.5 ppm. Death daphnids were counted under a stero microscope 24, 36, 48, 72 and 96 h intervals. The values of lethal concentration ($LC_{10, 50, 90}$) and Lethal time ($LT_{10, 50, 90}$) associated 95-99% confidence limits were calculated. Mortality rate between each dosages and mortality rate between 24-96 h depended on time were correlated. LC_{50} values were changed between 0.741-0.035, while LT_{50} values were found between 158 17- 4 25. Mortality ratios of *Daphnia magna* treated with malathion during 96 h period was found significant at 95-99% level ($p<0.001$-0.005).

Key words: DDVP, *Daphnia magna*, lethal concentration, lethal time

INTRODUCTION

Dichlorvos is an organophosphate compound used to control household, public health, effective against mushroom flies, aphids, spider mites, caterpillars, thrips, white flies in vegetable crops, mosquitoes and fish parasites. In aquatic systems for controlling mosquitoes space spray and surface spray methods are used. It is heavier than air and could be accumulated in water surface easily. In water, dichlorvos remains in solution and does not adsorb to hydrolysis with a half-life of approximately 4 days in lakes and rivers. Biodegration may occur under hydrolysis, or where populations of acclaimed micro organisms exist, as in polluted waters. DDVP has been estimated at 57 days from river and over 400 days from ponds[1,2].

Cladocerans, a group of freshwater zooplankton are broadly distributed in freshwater bodies present throughout a wide range of habitats are important links in many food chains. One of Cladoceran, *Daphnia* spp. are extensively used to investigate the acute/chronic toxicity of industrial and agricultural chemicals in aquatic ecosystems because they have a relatively short life cycle, require little space, are adaptable to laboratory conditions and are sensitive to a broad range of aquatic contaminants[3]. For these reasons, for determining the acut toxicity of DDVP, *Daphnia magna* was used.

MATERIALS AND METHODS

***Daphnia* culture:** *Daphnia magna* obtained from Fisheries Research Institute (Kepez-Antalya) and have been maintained in culture in our laboratory. The culture acclimated at under 20°C under 14/10 light/dark cycle Daphnids were fed with *Chlamydomonas* sp. The culturing period for one generation was 4 weeks before testing . They showed no sign of stress such as high mortality, presence of male and delay in production of first brood, discoloured animals, etc.

Test chemicals: DDVP ($C_4H_7CH_2O_4P$, Diclorvinyl-dimethhylphosphate) was used as test chemical. After many concentrations trial, 9 concentrations was decided for treatment. The test concentrations of DDVP were arranged in a geometric series between 0.001-0.5 ppm (0.002, 0.004, 0.008, 0.016, 0,032, 0.064, 0.125, 0.25 and 0.5 ppm). For each treatment, five replicates were used.

Toxicity tests: Daphnids were placed into test tubes (each 10 individual) containing 10 mL water. During the experiment period daphnids were not fed. The tubes acclimated at 20°C under 14/10 light/dark cycle during the study. A control group was used for each treatment.

Each DDVP concentration were put into the tubes with Microlit VVCS-10 micropipet and shaked carefully. The number of *Daphnia magna* in each tubes were counted under a stereo microscope after 24, 36, 48, 72 and 96 h later, the mortality rate of each group were determined. Toxicity tests were designed as in Ward and Parrish[4].

Statistic and quantitative structure activity relationship analysis: The values of Lethal concentration ($LC_{10,50,90}$) and Lethal time ($LT_{10,50,90}$) associated 95-99% confidence

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limits were calculated by appropriate statistical methods; either binomial, moving average or probit. In the toxicity tests a packet of computer programme (probit) was also used. The values were correlated with logarithm of concentrations. The results were converted to mg L^{-1} (ppm). Mortality rate between each dosages and mortality rate between 24-96 h depended on time was correlated[5-7].

RESULTS AND DISCUSSION

The lethal concentrations and lethal time of DDVP: Lethal concentrations of DDVP depending on time are given in Table 1. Twenty four hours LC_{10} value of DDVP was 0.116 ppm, while 96 h LC_{50} value was 0.035 ppm. Ninety Six hours LC_{10} value was 0.002 ppm, 96 h LC_{90} value was 1.1 ppm.

Lethal time of DDVP concentrations between 0.002-0.5 ppm are given in Table 2. LT_{10} was 61.36 at 0.002 ppm, while this time was determined 64.43 at 0.5 ppm. LT_{50} was 158.17 at 0.002 and 24.25 at 0.5 ppm. LT_{90} 320.00 at 0.002 and 73.37 at 0.5 ppm.

Correlation analysis applied to each concentration. In all concentrations the relationship between mortality ratio and time was found significant according to 95-99% confidence limit ($p<0.05-<0.01$) (Table 3).

Death ratios of *Daphnia magna* treated with DDVP during 96 h period was found significant at 95-99% level ($p<0.001-0.005$) (Table 4).

DDVP is a contact and stomach-acting insecticide. Entry into the aquatic environment may occur from diffuse inputs via land run-off and spray drift, by direct application (e.g in salmon farms) or from point discharges. Chemical and biological degradation results in half-lives of a few days[2].

For the protection of freshwater life a PEQS (provisional environmental quality standards) of 1 ng L^{-1} is proposed on applying an arbitrary safety factor of approximately 100 to the lowest acute 48 h LC_{50} of 70 ng L^{-1} for *Daphnia pulex* and 96 h LC_{50} of 100 ng L^{-1} for stonefly naiads[8]. In this study 48 h LC_{50} for *Daphnia magna* was determined as 0.159 ppm, 96 h LC_{50} was as 0.035 ppm.

In addition, if DDVP is applied directly to the aquatic environment (ie in salmon farms) it is suggested that 1 h after its release the maximum concentration outside a defined mixing zone should not exceed 25 μg L^{-1}, a concentration which did not result in mortalities or cumulative effect in lobster larvae exposed for repeated 6 h period[2]. The toxicity of DDVP to some species of fish is high (LC_{50} 0.5-1 mg L^{-1}) but unless the water is sprayed direct, the hazard is low in practice owing to relatively rapid hydrolysis[9]. Acute toxic level of DDVP on trout and daphnia were determined and LC_{50} value was found as 0.1 ppm on trout, 0.00007 ppm on Daphnia[1]. In this study 24 h LC_{50} value determined as 0.741 ppm, 96 h LC_{50} value as 0.035 ppm

Nacz *et al.*[10] investigated the effects of some pesticides on protozoan Spirostomum *ambiguum* and found 24 h EC_{50} value as 30 mg L^{-1} 24 h. The toxicity of three insecticides (carboran, dichlorvos, malathion) an herbiside (atrazine) and two metals (arsenic and cadmium) to ovigerous females, copepodids and nauplii of marine copepoda *Tigriopus brevicornis* were determined by 96 h semistatistic bioassays[11]. In the study LC_{50} value for ovigerous *T. brevicornis* females was 4.6 μg L^{-1} for dichlorvos. Comparison of overall toxicities of these pesticides and metals indicated that dichlorvos was the most toxic substance to *T. brevicornis*[11]. In this study LC_{50} values were changed between 0.741-0.035 ppm.

In conclusion, DDVP is among the highly toxic pesticide. Aquatic organisms are more sensitive to DDVP than Avian and Mammalian[1]. In aquatic systems in controlling mosquitoes and flies, less hazardous chemicals or biological methods should be used instead of DDVP.

Table 1: Lethal concentrations (LC_{10}, LC_{50}, LC_{90}) of DDVP depending on time LT (h)

Concentrations (ppm)	Time (h) 24	36	48	72	96
LC_{10}	0.116	0.038	0.007	0.002	0.002
LC_{50}	0.741	0.202	0.159	0.061	0.035
LC_{90}	1.371	1.259	1.208	1.152	1.100

Table 2: Lethal time (LT_{10}, LT_{50}, LT_{90}) of DDVP concentrations

	Concentrations (ppm)								
LT (h)	0.002	0.004	0.008	0.016	0.032	0.064	0.125	0.25	0.5
LT_{10}	61.36	52.49	32.00	38.58	34.02	28.57	23.20	17.37	64.43
LT_{50}	158.17	116.47	109.34	104.37	98.09	90.19	70.33	50.05	24.25
LT_{90}	320.00	206.24	204.00	178.49	171.21	156.40	148.30	140.39	73.37

Table 3: The correlation coefficients, standard error (SE) and levels of significance (p) between mortality rate and exposure times (24, 36, 48, 72 and 96 h) of each DDVP concentration

Malathion concentrations (ppm)	Correlations of exposure times	SE	p-value
0.001	-	-	-
0.002	0.989	0.086	<0.01
0.004	0.966	0.150	<0.01
0.008	0.965	0.152	<0.01
0.016	0.984	0.013	<0.01
0.032	0.975	0.129	<0.01
0.064	0.953	0.175	<0.01
0.125	0.933	0.207	<0.05
0.25	0.908	0.242	<0.05
0.5	0.872	0.283	<0.05

Table 4: The correlation coefficients, standard error (SE) and levels of significance (P) between mortality rate and concentrations of DDVP

Exposure times (h)	Correlations of Malathion concentrations	SE	p-value
24	0.845	0.234	<0.01
36	0.920	0.185	<0.01
48	0.956	0.099	<0.01
72	0.979	0.090	<0.01
96	0.977	0.116	<0.01

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