

PERSISTENCE OF MOSQUITO LARVICIDES IN WATER¹

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INTRODUCTION. Larvicidal treatments constitute a major portion of mosquito control operations in California. As a result of a systematic search for more effective larvicides having favorable mammalian toxicity, numerous highly effective materials were found. (Mulla *et al.*, 1960, 1961, 1962).

Residual and long-lasting materials that would yield prolonged control of mosquito larvae are often sought. On the other hand, materials with short persistence may be applied more advantageously to breeding sources where residual activity may create undesirable conditions for wildlife and game species, and create persistent water pollution with insecticides. To gather information on the persistence of mosquito larvicides in water, several materials were studied both in the laboratory and field.

METHODS AND MATERIALS. For laboratory evaluation, 4 percent emulsifiable concentrates were prepared, using technical grade materials; 0.4 gm. of the technical material plus 0.2 gm. of Triton X-100 were dissolved in Espesol 5 solvent and the volume was brought up to 10 ml.

For persistence or disappearance tests, 0.175 ml. of the 4 percent emulsifiable concentrate was added to 3500 ml. of tap water (pH 8) in a gallon mason jar; this yielded an initial concentration of 2 p.p.m. toxicant in the water. Jars containing the treated water were placed under constant fluorescent light with an incident light intensity of 64 foot-candles at the surface of the water and a constant temperature of

95° F. Water lost from the jars due to evaporation was replenished at each interval.

At intervals of 0, 24, 48, 72 and 96 hours, aliquots of the treated water were taken while being stirred mechanically in the jar, and were added to 100 ml. of tap water in 6 oz. paper cups. Each cup contained 25 fourth instar larvae of *Culex p. quinquefasciatus* and was replicated 3 times. The aliquots of treated water added to the cups were adjusted to give 98 percent to 100 percent larval mortality. The larvae were kept at a temperature of 78° F. during the exposure period and larval mortality was read 24 hours after exposure. The amount of toxicant corresponding to larval mortality was calculated from dosage-response lines of the various materials established against *C. p. quinquefasciatus* (Mulla *et al.*, 1960, 1961, 1962).

In field studies, 1/16 acre ponds (Mulla and Isaak 1961) were treated with multiple rates by means of hand sprayers. Proprietary emulsifiable concentrates were used in preparing the dilute sprays which were applied at the rate of 8 gallons per acre. The ponds were filled with water to a depth of 8 to 12 inches.

Within 1 to 2 hours after treatment, samples of water from the surface were transferred from the ponds into quart fruit jars. The jars were closed tightly and transferred to the laboratory in a cool ice chest. The water in the jars was kept refrigerated until tests were completed.

Aliquots of the treated pond water giving various dilutions were transferred to paper cups containing 4th instar mosquito larvae and tap water. The procedure thereafter was the same as that followed in the laboratory.

RESULTS AND DISCUSSION. Twenty-four insecticides were studied for their persistence in tap water in the laboratory (Table 1). Among these, AC-5727, Bayer 30749,

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TABLE 1.—Persistence of mosquito larvicides in water applied as emulsion concentrates in the laboratory.¹

Insecticide	Avg. percent mortality after hours					Insecticide present in water (p.p.m.) after hours				
	0	24	48	72	96	0	24	48	72	96
AC-5727	98	34	14	2	0	2.00	1.07	0.90	<0.70	<0.70
Bayer 25141	100	100	100	100	100	2.00	2.00	2.00	2.00	2.00
Bayer 29492	100	100	100	99	100	2.00	2.00	2.00	2.00	2.00
Bayer 29493	100	100	100	96	94	2.00	2.00	2.00	2.00	1.87
Bayer 30749	100	88	50	4	2	2.00	1.76	1.23	<0.80	<0.71
Bayer 34042	100	100	100	100	100	2.00	2.00	2.00	2.00	2.00
Bayer 38108	100	100	100	100	100	2.00	2.00	2.00	2.00	2.00
Bayer 38156 ²	82	27	5	12	9	1.40	0.63	0.43	0.50	0.47
Trithion	100	100	100	100	100	2.00	2.00	2.00	2.00	2.00
Methyl Trithion	100	100	100	100	100	2.00	2.00	2.00	2.00	2.00
G-27365 ^{2 3}	100	34	10	32	20	2.00	1.03	0.73	1.00	0.87
G-28029 ³	100	88	60	73	81	2.00	1.42	1.02	1.18	1.28
G-30493	100	99	92	96	97	2.00	2.00	1.80	1.95	2.00
G-30494 ³	100	39	30	55	29	2.00	1.56	1.48	1.66	1.46
GC-3582	100	100	98	54	57	2.00	2.00	2.00	1.06	1.09
GC-3583	99	98	100	99	92	2.00	2.00	2.00	2.00	1.75
GC-4072	98	100	92	62	87	2.00	2.00	1.64	1.22	1.54
OMS-8 ²	100	65	22	19	13	2.00	1.40	1.02	1.00	0.93
OMS-3 ²	100	0	0	..	..	2.00	<0.39	<0.39	..	..
OMS-115	100	98	98	98	99	2.00	2.00	2.00	2.00	2.00
Malathion ²	100	88	0	..	..	2.00	1.20	<0.27	..	..
Methyl parathion	100	99	91	90	71	2.00	1.90	1.22	1.20	1.00
Parathion	100	100	100	100	100	2.00	2.00	2.00	2.00	2.00
SD-4402	100	100	100	100	100	2.00	2.00	2.00	2.00	2.00

¹ Average temperature of water was 95° F.

² After washing glass jar with acetone, and bioassaying the acetone wash solution, 23 percent of G-27365 was found to be absorbed onto the glass jar. Bayer 38156, OMS-8, OMS-3 and malathion showed no absorption to glass surface of the jar.

³ Average of four experiments. All others were either one or two experiments.

Bayer 38156, G-27365, G-28029, G-30494, OMS-8, OMS-3 and malathion disappeared from the water rapidly; G-3582, G-3583, G-4072 and methyl parathion also disappeared from the water, but at a slower rate. The remaining 11 materials (See Table 1) showed no appreciable decline during the 4 days of testing.

The disappearance of toxicants from the water in the laboratory tests may be due to several chemical and physical factors. The chemicals may be degraded by chemical processes to non-toxic constituents. Breakdown due to light may also account for the degradation of certain chemicals. Co-distillation with water and absorption of the toxicants on the glass surfaces of the jar may also play a role in the disappearance of the toxicants from the water. It is notable (Table 1) that 23 percent of G-27365 was absorbed on the glass surface.

The solvent-emulsifying agent combination may have produced an unstable system for some toxicants but not for others.

In the field tests, 21 larvicides were evaluated at multiple dosages for their persistence in water (Table 2). Materials which lost less than 50 percent of their activity at any of the low to moderate dosages (0.1 to 0.8 lb./acre) after 24 hours were Bayer 29952, Bayer 34042, Bayer 37289, Bayer 38020, GC-3582, Ethyl Guthion®, parathion, methyl parathion, Diazinon®, Bayer 37342, OMS-3 and OMS-115. The remaining nine materials disappeared rather rapidly from the water.

Among the materials tested both in the laboratory and field, Bayer 30749, G-27365, G-28029, OMS-3 and G-30494 were less persistent under both conditions. Bayer 34042, OMS-115, methyl parathion and parathion were more persistent in both

TABLE 2.—Persistence of mosquito larvicides in water treated in field plots as determined by mosquito larval bioassay, 1961.

Materials and formulation	Toxicant lbs./acre	% Disappearance hours after treatment ^a		
		24	48	72
G-28029 EC 2	.4	89	..	..
	1.6	82	..	..
G-27365 EC 2	.2	100	100	..
	.4	79	100	..
	.8	71	77	..
G-30404 EC 2	.8	52	90	96
Bayer 29492 EC 2	.2	81	86	90
	.8	73	78	85
Bayer 29952 EC 2	.1	60	..	..
	.4	40	..	..
Bayer 30749 EC 4	.8	*	75	..
Bayer 34042 EC 4	.1	72	86	..
	.4	33	48	..
Bayer 37289 EC 4	.8	24	41	82
Bayer 41831 EC 4	.2	69	..	..
	.8	68	..	..
	1.6	17	54	*
Bayer 38920 EC 4	.5	0	60	..
	2.0	0	47	..
GC-3582 EC 4	.2	0	25	100
	.4	59	53	76
	.8	27	55	75
	1.6	41	..	..
Ethyl Guthion EC 2	.1	60	100	..
	.2	58	..	..
	.8	29	..	..
Trithion EC 4	.2	77	100	100
	.4	65	74	..
	1.6	24	60	..
Dibrom EC 8	.5	100	100	..
	2.0	70	100	..
Parathion EC 2	.1	50	82	100
	.4	0	30	86
Methyl parathion EC 7.5	.4	5	62	75
	.8	24	88	93
TD-72 EC 6.7	.5	100	..	..
	2.0	100	..	..
Diazinon EC 2	.3	38	38	62
	1.2	18	46	*
Bayer 37342 EC 4	.4	8	100	100
	1.6	6	61	67
OMS-3 EC 2	.5	36	100	100
	1.0	15	100	100
OMS-115 EC 2	.5	0	36	..
	2.0	30	55	72

* Jar containing water sample broken in transit to laboratory.

^a Percent disappearance is based on the toxicant amounts present 1 hour after treatment. One hundred percent disappearance is indicated only when no mortality was obtained by using undiluted treated water. This does not necessarily mean that the total quantity of the insecticides was lost.

testing procedures. Bayer 29492 and Trithion gave different persistence trends in the laboratory and in the field studies.

In the field, several physio-chemical and biological factors, in addition to those pre-

vailing in the laboratory are encountered. Wind action, percolation rate of water through the ground, light intensity, breakdown by microorganisms, presence of organic matter in the water, and finally the

CHEMICAL DESIGNATIONS OF PROPRIETARY MATERIALS

AC 5727	<i>m</i> -isopropylphenyl N-methyl carbamate
Bayer 25141	<i>O,O</i> -diethyl <i>O</i> - <i>p</i> -(methylsulfinyl) phenyl phosphorothioate
Bayer 29492	<i>O,O</i> -diethyl <i>O</i> -[4(methylthio)- <i>m</i> -tolyl] phosphorothioate
Bayer 29493	<i>O,O</i> -dimethyl <i>O</i> -[4(methylthio)- <i>m</i> -tolyl] phosphorothioate
Bayer 29952	<i>O</i> -ethyl <i>O</i> - <i>p</i> -methylthiophenyl methylphosphonothioate
Bayer 30749	<i>O</i> -ethyl <i>O</i> - <i>p</i> -ethyl sulfinylphenyl methylphosphonothioate
Bayer 34042	<i>O</i> -ethyl <i>O</i> -(3-methyl-4-methylthiophenyl) N-methyl phosphoramidothioate
Bayer 37342	<i>O,O</i> -dimethyl <i>O,O</i> -(3,5-dimethyl-4-methylthiophenyl) ethyl phosphorothioate
Bayer 38156	<i>O</i> -ethyl <i>S</i> - <i>p</i> -methylphenyl ethyl phosphonodithioate
Bayer 38920	6,7,8,9,10,10-Hexachloro-1,5,5a-6,9,9a-Hexahydro-3-methyl-3-methyl-6,9-methano-2,4-benzodioxepin
Bayer 41831	<i>O,O</i> -dimethyl <i>O</i> -3-methyl-4-nitrophenyl phosphorothioate
Diazinon ®	<i>O,O</i> -diethyl <i>O</i> -(2-isopropyl-4-methyl-6-pyrimidyl) phosphorothioate
Dibrom	1,2-dibromo-2,2-dichloroethyl dimethyl phosphate
Ethyl Guthion ®	<i>O,O</i> -diethyl <i>S</i> -4-oxo-1,2,3 benzotriazin-3(4H)-ylmethyl phosphorodithioate
Trithion ®	<i>O,O</i> -diethyl <i>S</i> -(<i>p</i> -chlorophenylthiomethyl) phosphorodithioate
G-27365	<i>O,O</i> -diethyl <i>S</i> -(3,4-dichlorophenylthio)-methyl phosphorodithioate
G-28029	<i>O,O</i> -diethyl <i>S</i> -(2,5-dichlorophenylthio)-methyl phosphorodithioate
G-30493	<i>O,O</i> -dimethyl <i>S</i> -(3,4-dichlorophenylthio)-methyl phosphorodithioate
G-30494	<i>O,O</i> -dimethyl- <i>S</i> -2,4-dichlorophenyl mercaptomethyl phosphorodithioate
GC-3582	Diethyl-1-(2,5-dichlorophenyl)-2,2-dichlorovinyl phosphate
GC-3583	Diethyl-1-(2,5-dichlorophenyl)-2-chlorovinyl phosphate
GC-4072	Diethyl-1-(2,4-dichlorophenyl)-2-chlorovinyl phosphate
Methyl Trithion ®	<i>O,O</i> -dimethyl <i>S</i> -(<i>p</i> -chlorophenylthiomethyl) phosphorodithioate
OMS-3	<i>O</i> -methyl <i>O</i> -2,4,5-trichlorophenyl phosphoramidothioate
OMS-8	<i>O</i> -ethyl <i>O</i> -(2,4,5-trichlorophenyl) methyl phosphoramidothioate
OMS-115	<i>O</i> -methyl <i>O</i> -(2,4-dichlorophenyl) isopropylphosphoramidothioate
SD-4402	1,3,4,5,6,7,8,8-octachloro 3,4,4',7,7' tetrahydro-4,7-methanophthalan
TD-72	<i>O,O</i> -diethyl <i>S</i> -(<i>N</i> -ethoxycarbonyl- <i>N</i> -methyl carbamoylmethyl) phosphorodithioate

numerous complex edaphic factors may greatly influence the disappearance of toxicants from water. Absorption of toxicants on the soil colloids is undoubtedly important in the removal of toxicants from water. Further studies on this and other phases of mosquito larvicides are necessary in order to understand fully the longevity and persistence of these mosquito control agents.

Unlike the results of the laboratory tests, most of the materials evaluated in the field disappeared rapidly from the water. In most cases, over two-thirds of the initial concentration was lost from the water after 72 hours. Whether or not most of this lost portion is absorbed on the soil particles and released in water, subsequently, is yet to be investigated. Studies on the toxicity of some of these materials to the mosquito fish *Gambusia affinis* in the field (Mulla and Isaak, 1961; Mulla *et al.*, 1963) for long periods suggest that this is true.

From the standpoint of water pollution

by insecticides it is apparent that most of the organophosphate compounds applied at mosquito larvicidal rates (lowest dosage of each material in Table 2) disappear rapidly from the treated water. The water pollution problem with mosquito larvicides, therefore, seems to be a temporary one since a major portion of the materials applied disappears within 24 hours.

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