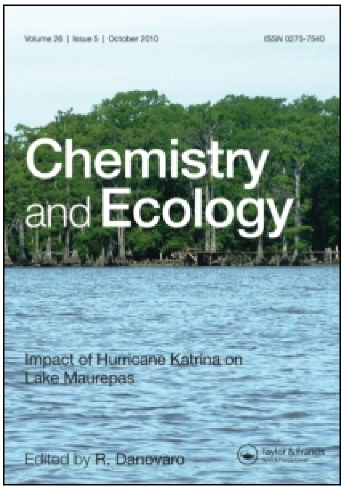

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ASSIMILATION OF FENTHION IN COASTAL WATER

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AERIAL SPRAY OF FENTHION IN COASTAL WATER

Fenthion [0.0-dimethyl 0-3-methyl-4(methylthio) phenyl phosphorothioate] is one of the most used mosquito insecticides in Florida, USA. Aerially applied insecticides may accidentally drift into estuarine coastal water and affect non-target organisms (Johnson and Finley, 1980; Kenaga, 1979; Patterson and Von Windeguth, 1964; Ray and Stevens, 1970). A field spray and a laboratory study were conducted to determine the persistence and disappearance rates of fenthion in the water and its toxicity on non-target organisms. This paper summarizes the results of the study and determines the assimilation capacity of fenthion in coastal waters. The fenthion is often applied as a thermal fog by a DC-3 aircraft. The thermal fog mixture contains 1.5% fenthion, 33.5% fog oil and 65% No. 2 diesel fuel. The spray duration was one to two minutes as the plane made its swath directly over the target site. The field spray was in St. Lucie County Impoundment on the east coast of Florida, USA. Before and after the spray, water samples were collected at different time intervals up to 48 hours to determine the fenthion concentration and their disappearance rates in the coastal water (Wang *et al.*, 1987).

In most cases, less insecticide reached ground level than would be expected from the application rate. Table 1 shows the fenthion deposits on the water surface 12 minutes after spraying. The maximum amount of fenthion deposited on the water surface occurred in test one and was determined to be 18.6 ng/cm^2. This represents only 5.4% of the application rate. The remaining fenthion could have undergone volatilization or degradation during the aerial spray.

The highest peak concentration was 1.69 μg/l fenthion at 45 minutes after the spray. The concentration then gradually decreased to a non-detectable level after 24 hours. Fenthion droplets once deposited on the water surface were immediately dispersed and diluted in the water. Tidal flushing moved and transported the insecticide in the water, playing an important role in the disappearance of fenthion. Water quality data and fenthion concentration in the water are shown in Table 1.

Table 1 Data from field tests. Fenthion thermal fog was applied by DC-3 Aircraft. C = Control Site; S = Spray Site.

Test no.	*Site*	*Temp. (°C)*	*Salinity (‰)*	*pH*	*Dissolved oxygen (mg/l)*	*Amount deposited*			*Peak concent.*		*Persist. (h)*	*Mosquito mortality (%)*
						Expected (ng/cm²)	*Observed (ng/cm²)*	*Obs./Exp. (%)*	*(μg/l)*	*min.*		
1	C	24.8–32.7	22–25	7.8	1.6–13.2	—	—	—	—	—	—	2
	S	25.2–29.2	20–27	7.2	0.9– 5.8	342	18.6	5.4	1.69	45	24	54
2	C	21.8–27.5	34–36	6.8–7.4	2.8–11.2	—	—	—	—	—	—	3
	S	22.7–26.0	35–38	6.5–7.2	1.5–12.4	342	0.88	0.3	≤0.01	19	24	94
3	C	27.3–34.4	36–39	7.3–8.0	0.4–10.7	—	—	—	—	—	—	2
	S	28.2–33.1	35–40	7.3–7.8	0.4– 5.9	342	1.24	0.4	0.16	46	18	96
4	C	27.4–33.9	30–34	5.9–8.0	0.5– 9.1	—	—	—	—	—	—	3
	S	29.1–32.4	30–34	6.5–8.1	2.3– 9.3	342	0.39	0.1	0.16	45	24	96

Table 2 Exposure-related mortality among organisms in field tests expressed as the difference between mortality at the sprayed site and that observed at the control site. In some, mortality at the spray site was ≤ mortality at the control site (n.s. = non-significant)

Test	*Animals*	*Exposure-related mortality (mean % ± 95% CI)*
Thermal Fog Tests		
1 Fenthion (aerial)	Copepod adults	n.s.
2 Fenthion (aerial)	Copepod adults	52.3 ± 12.8
	Gulf menhaden eggs	n.s.
3 Fenthion (aerial)	Copepod adults	n.s.
	Spotted sea trout eggs	n.s.
4 Fenthion (aerial)	Common snook eggs	n.s.

EFFECT OF FENTHION SPRAY ON NON-TARGET ORGANISMS

The field tests also included observations of mortality of caged animals placed at both control and testing sites. Animals tested included adults of a calanoid copepod, Gulf menhaden eggs, spotted sea trout eggs and common snook eggs. Observations at the test site assessed the effect of insecticide exposure and those at the control site assessed the health of test animals, including possible effects of capture and handling (Tucker *et al.*, 1987). Table 2 shows statistically significant mortality occurred only for copepods exposed to fenthion thermal fog in test 2. The occurrence of significant mortality among controls in the field tests indicates that environmental factors (i.e. water quality) played an important role in the sensitivity of copepods to the insecticides. Although fenthion concentration in test 2 was low because of differences in spraying, degradation or settling, a large amount of oil could have settled on the water. Significant mortality of fish was not observed. Laboratory acute toxicity tests with adult copepods and fish eggs and juveniles (Tucker *et al.*, 1985) predicted that only copepods would be sensitive to the concentrations of fenthion in the thermal fog, especially at high temperatures and salinities (30°C, 35‰).

PERSISTENCE OF FENTHION IN COASTAL WATERS

Fenthion, once deposited to the coastal water, normally undergoes chemical, photochemical and biological processes: these degradation pathways depend on the presence of light, temperature, alkali, or enzymatic activity (Menzies, 1966). A laboratory study was performed to evaluate the effect of pH, salinity, natural sunlight and biological activities in the coastal water (Wang *et al.*, 1989). The results show that fenthion remains relatively stable under acidic to neutral conditions. Under alkaline conditions, fenthion still remained stable until the pH range exceeded 11. The effect of raising the pH from 9 to 11 reduced the half-life by approximately a factor of 7. Higher salinity also resulted in a shorter half-life; however, when compared to biologically active water, this ionic effect would probably be secondary in nature. Mangrove swamp water that was kept in the

Table 3 Characteristics of natural waters

Sample type	*pH*	*Salinity* (‰)	*Conductivity* ($\mu\Omega$)	NH_4 (*ppb*)	$NO_2 + NO_3$ (*ppb*)	PO_4 (*ppb*)	*Sampling location* (*Florida S.E. Coast*)
Mangrove Swamp	7.3	16.0	3.0×10^4	110.8	248.4	161.4	Mosquito Imp. #24 St. Lucie County
Estuarine	7.9	32.0	5.5×10^4	65.6	23.2	142.4	Indian River Lagoon
Inlet Water	8.0	35.0	6.4×10^4	44.3	24.3	89.3	Fort Pierce Inlet
Ocean Water	8.0	36.0	6.5×10^4	23.8	10.8	57.9	50 Miles Offshore
Freshwater Canal	7.8	0.0	1.4×10^3	71.6	118.8	246.9	Vero Beach Main Canal
Fresh/Salt Water Confluence	7.8	6.0	1.15×10^4	47.7	97.2	284.9	Main Canal and Indian River
Freshwater Lake	8.4	0.0	1.4×10^3	90.3	27.0	83.6	Lakewood Park, Fort Pierce

dark and sterilized exhibited the longest half-life (46.9 days). The sample that was not sterilized but kept in the dark showed a reduction in the half-life of approximately 2 fold (19.7 days). This indicates that fenthion is susceptible to biological degration by anaerobic or non-photolytic organisms. The half-life was reduced to 10.9 days in the sterilized sample when exposed to natural sunlight. However, the sample exposed to natural sunlight and not sterilized had the shortest half-life (2.9 days). This shows that photolytical degradation plays a more important role than that of biological degradation in the swamp water.

Fenthion degradation data in various types of coastal waters was determined. Different types of natural water was collected and incubated in the pond with natural sunlight. The characterization of natural water collected is shown in Table 3. With the same natural sunlight exposure, the half-life of fenthion in the natural waters seemed to be related to the biological activity. If we were to assume that NH_4^+ concentration is an indicator of biological activity for the coastal and saline waters than it can be seen that the mangrove water with the highest NH_4^+ concentration (110 μg/l) had the lowest half-life (2.9 days), while the ocean water with the lowest NH_4^+ concentration (23.8 μg/l) had the longest half-life (21.1 days). Table 4 shows that under naturally occurring conditions, photolysis and biological degradation are the two dominant pathways for fenthion degradation. Fenthion is more persistent in off-shore ocean water than in coastal mangrove swamp water.

Table 4 Fenthion degradation rate constants for various natural waters (field study)

Water type	*Half-life* (*days*)
Offshore Ocean	21.1
Ocean Inlet	5.6
Confluence	5.3
Indian River	4.2
Mangrove Swamp	2.9
Freshwater Lake	10.9
Freshwater Canal	4.3

SUMMARY

Aerial application of fenthion, 0.0-dimethyl 0-[3-methyl-4-(methylthio)phenyl] phosphorothioate, is widely used to control adult mosquito populations in the Florida coastal marshes. Although not sprayed on water intentionally, aerial spray may accidentally drift into estuarine, coastal and offshore waters. Laboratory and field studies were previously conducted to determine the assimilation capacity of fenthion in coastal water and its effects on non-target organisms. Fenthion, once deposited to the coastal water, normally undergoes chemical, photochemical and biological processes. The effect of pH, salinity, natural sunlight and biological activities in the coastal water are discussed. The half-life of fenthion in the offshore, inlet coastal water, estuarine and mangrove swamp waters were found to be 21.1, 5.6, 4.2 and 2.9 days, respectively. In natural conditions, photolysis and biological activities are the two dominant pathways for assimilating fenthion in the water. Four aerial field studies were also conducted to investigate the deposition rate of fenthion in the water. The deposition rate of fenthion aerial spray into the coastal water and its acute toxicity on non-target estuarine organisms were determined. After each spray, fenthion concentration was normally increased and peaked at 45 minutes and then gradually decreased. After 24 hours, only a trace of fenthion ($\leqq 0.01\,\mu g\,L^{-1}$) was detected. Animal toxicity tests conducted in the field included adults of the calanoid copepod, *Acartia tonsa*, eggs and juveniles of three species of fishes. Statistically, significant mortality occurred only for copepods in one of the four tests. Water quality such as temperature could play an important role in the sensitivity of copepods to the fenthion.

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