MALATHION AEROSOL CLOUD BEHAVIOR IN A COASTAL PLAINS PINE FLATWOODS[1]

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ABSTRACT. The study examines malathion aerosol cloud behavior in a North Florida pine flatwoods. Droplet mass median diameters (MMD) decreased over distance in both open and pine flatwoods. A sharp decrease in number of aerosol droplets per cm^2 occurred between 3.1 and 15.2 m and a gradual decline in droplets per cm^2 occurred beyond 15.2 m in both treatment areas. There were no interactions between habitat and distance in regard to MMD or droplets per cm^2. Analysis of variance models accounted for 82% of the variability in the MMD data and 79% of the variability in the number of droplets per cm^2.

Recent research has addressed the effects of a citrus grove on the dispersion of adulticides (Curtis and Mason 1988) and the effects of vegetation as found in a typical residential area (Panama City, FL) on the dispersion of 91% malathion (Rathburn and Dukes 1989). Inadequate mosquito control and the requirement for the maximum labeled rate for ground ULV application of malathion to approach 90% mortality in caged mosquitoes, respectively, were shown in vegetated areas for both studies. Understanding aerosol cloud behavior and the deposition of insecticide on vegetation will enhance the ability of disease vector control personnel in establishing disease vector barriers. The purpose of this study was to examine malathion aerosol cloud behavior in a coastal plain, pine flatwoods.

The study area was located on the Naval Air Station, Jacksonville, Florida. The predominate vegetation consisted of *Pinus palustris* Miller (longleaf pine) with an understory of *Sabal minor* Persoon (Jacquin) (palmetto) and mixed shrubs. Vegetation density was estimated using plant height within 10 randomly selected plots 3.1 m in diameter, with the following results (mean number of plants per area ± SD): <1.0 m in height (1.0 ± 1.3), 1.0–3.0 m in height (1.6 ± 1.5) and >3.0 m in height (2.4 ± 1.6). An open field consisting of mixed grasses (average height = 15 ± 2 cm) was utilized as the contrasting area.

Aerosol droplets were collected with rotating impingers (John W. Hock Company, Gainesville, FL 32604) using Teflon® coated slides, stationary Teflon slides and oil sensitive paper (TeeJet®, Spraying Systems Co., Wheaton, IL 60188). Impingers were mounted at 0.3 and 1.5 m on stands placed at the woodline and every 15.2 m into the pine flatwoods for a downwind distance of 121.9 m. Impingers were oriented perpendicular to the path of the truck-mounted ULV machine. Dye cards were stapled 0.7 m high on the vertical impinger stands. Stationary slides were placed horizontally on the impinger base at ground level. Each slide was sealed in a box after sampling and read within 3 hours. Slides not read within 3 h were covered with a paper gasket, an additional plain glass slide and taped to prevent evaporation of the insecticide droplets (Anonymous 1985) and then read within 24 hours. Droplet measurements were then performed within 24 hours.

Droplets were collected between 0700 and 0900 h under the following environmental conditions: RH 60–80%, wind speed 2–5 mph, ambient temperature 24–28°C. An electrically driven ULV generator (Whispermist 10®, Beecomist Systems, Inc., Telford, PA 18969) generated the aerosol cloud. The machine was calibrated for a 91% malathion concentration (American Cyanamid, Wayne, NJ 07470) with a flow rate of 4.0 fl oz per min at a vehicle speed of 10 mph. The ULV generator was turned on 31 m before the line of impingers and turned off 31 m after passing the test plot. Each experiment was replicated twice. A minimum of 100 droplets on each slide was measured with a compound microscope. The number of droplets occurring per cm^2 on slides were calculated by the following formula (for a one-inch wide slide and an ocular micrometer 500 μ wide):

$$\left(\frac{25{,}400\ \mu/\text{in}^2}{(\text{No. of sweeps to count 100 drops})\ (500\ \mu)}\right) \cdot 100\ \text{drops} = \frac{\text{No. drops}}{\text{in}^2}$$

The number of droplets per cm^2 on oil sensitive paper was counted with a "centimeter template." Droplet counts within 3 randomly selected areas on each slide were averaged. Droplet

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numbers were then converted to $\log_e$ (drops + 1) for regression analysis. The variability between the 0.3 and 1.5 m impinger heights was low, and therefore, combined for statistical analysis. The MMDs were calculated using ULVDROPS (Haile et al. 1987). The resulting MMDs and droplets per cm^2 were then subjected to an analysis of variance using the SAS program (SAS Institute 1985).

Mass median diameters: Regression analysis on the impinger data alone demonstrated significant differences among distances with MMD decreasing over distance in both the open field [$P < 0.0001$, MMD = 23.9 − 0.096(DIST), r^2 = 0.15, df = 1] and pinewoods [MMD = 21.3 − 0.02(DIST), r^2 = 0.34, df = 1] (Table 1). There was also a significant difference between the 2 habitats [$P < 0.0001$, MMD = 21.6 − 0.01115(DIST), r^2 = 0.15, df = 1] with the larger MMDs being collected in the open field. There was no interaction between distance and habitat (i.e., differences between the habitats did not depend on distance, so that plots of MMD against distance for the 2 habitats were "parallel"). The analysis of variance model accounted for 82% of the variability in the data.

Table 1. Mass median diameters[1] (±SD), aerosol droplets per cm^2 and percent mortality in an open field and lightly vegetated habitat.[2]

Distance (m)	Mass median diameters[3] Open field	Pine flatwoods
3.1	27.1 ± 5.2	23.2 ± 3.5
15.2	20.8 ± 0.7	19.9 ± 0.2
30.5	20.3 ± 0.8	18.7 ± 1.4
45.7	21.6 ± 2.5	16.8 ± 0.1
60.9	26.5 ± 1.1	17.7 ± 3.2
76.2	21.6 ± 2.6	18.6 ± 2.5
91.5	19.4 ± 1.2	16.8 ± 0.7
106.7	18.9 ± 0.1	16.1 ± 0.3
121.9	21.1 ± 0.6	—
x̄ = 2	1.9 ± 2.9	18.5 ± 2.3

[1] Impinged Teflon® slides.
[2] Means of 2 replications.
[3] Regression equations: open field: MMD = 23.9 − 0.0096 (DIST), $P \leq 0.0001$, r^2 = 0.15, df = 1; Pinewoods: MMD = 21.3 − 0.02 (DIST), $P \leq 0.0001$, r^2 = 0.34, df = 1.

Droplets per cm^2: Regression analysis also demonstrated significant differences [Open field: $\log_e$ (drops + 1) = 6.2 − 0.008(DIST), $P <$ 0.0001, r^2 = 0.58, df = 1; Pinewoods: $\log_e$ (drops + 1) = 6.8 − 0.009(DIST), $P < 0.0001$, r^2, df = 1], the 3 collection methods and between habitats ($\log_e$ (drops + 1) = 6.7 − 0.009(DIST), $P <$ 0.0001, r^2 = 0.56, df = 1] in regard to aerosol droplets per cm^2 (Table 2). The sharpest decrease in aerosol droplets per cm^2 was between 3.1 and 15.2 m in both habitats. The impinger collected a greater number of droplets than oil sensitive paper or the stationary slides (Table 2). There was no interaction between distance and method. The analysis of variance model accounted for 79% of the variability in the data.

In a preliminary test, the number of droplets per cm^2 required for 80% mortality ranged from 142 in the open field to 796 in the pine flatwoods (unpublished data). Although the variability demonstrated may be normal for this type of test (Table 2), it does not allow for the calculation of a number of droplets per cm^2 required to achieve 80% mortality at any distance. This variability is probably due to microclimate wind shifts encountered by the aerosol cloud as it drifted downrange. Additional work, utilizing other insecticides, application equipment and habitats will offer insight into the effects of vegetation on aerosol cloud behavior.

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Table 2. Aerosol droplets per cm^2 (±SD) on stationary Teflon® slides, dye cards and impinged Teflon® slides in an open field and pine flatwoods at selected distances.[1]

Habitat	Distance (m)	No. of droplets per cm^2		
		Stationary slides	Dye cards	Impinger slides
Open field	3.1	25 ± 40[2]	574 ± 294	4,225 ± 423[3]
	15.2	1 ± 1	27 ± 31	678 ± 280
	30.5	1 ± 1	42 ± 39	142 ± 54
	45.7	0	0	18 ± 7
	60.9	0	0	67 ± 3
	76.2	0	0	76 ± 25
	91.5	0	0	36 ± 6
	106.7	0	0	32 ± 3
	121.9	0	0	0
	$\bar{x}$ =	3.0 ± 8.3	71 ± 189	659 ± 1,457
Pine flatwoods	3.1	32 ± 24	1,932 ± 1,358	3,899 ± 167[3]
	15.2	4 ± 9	730 ± 1,059	796 ± 21
	30.5	0	602 ± 829	366 ± 269
	45.7	0	280 ± 256	107 ± 84
	60.9	0	0	54 ± 10
	76.2	0	0	370 ± 86
	91.5	0	0	64 ± 3
	106.7	0	0	41 ± 7
	121.9	0	0	0
	$\bar{x}$ =	4 ± 10.6	394 ± 643	633 ± 1,251

[1] Means of 2 replications.
[2] Rounded to the nearest whole number.
[3] Regression equations for impinger droplets only: Open field: $\log_e$ (drops + 1) = 6.2 − 0.008 (DIST), $P \leq 0.001$, $r^2 = 0.58$, df = 1; Pinewoods: $\log_e$ (drops + 1) = 6.8 − 0.009 (DIST), $P \leq 0.0001$, $r^2 = 0.47$, df = 1.