OPERATIONAL AND SCIENTIFIC NOTES

ULV DROPLET SPECTRA: COMPARATIVE ANALYSIS OF SIX DROPLET COLLECTION METHODS[1]

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ABSTRACT. Three distances (1.2, 3.0 and 7.6 m) and 4 methods (complete diagonal swing, impinger, top diagonal swing and vertical swing) were compared in analyzing the droplet spectra of electrically generated ULV aerosol clouds. There were no significant differences among the 4 methods and no interaction between method and distance. However, when compared over distance, the percent variability indicated the complete diagonal swing provided the most consistent results. Two additional methods (pendulum and settling chamber) were compared with the original 4 methods at 1.2 m only. At this distance, there was no significant difference among the 6 methods.

Since the effectiveness of ultra low volume (ULV) application of insecticides for mosquito control was demonstrated over 2 decades ago (Mount et al. 1968), almost all ground vehicle mounted ULV generators have depended on a compressor powered by a gasoline engine to atomize the insecticide. Consequently, all previously reported droplet spectra studies have employed gasoline powered ULV generators to produce droplets. More recent developments in the industry have utilized an electrically driven rotary head spinning at high RPM to generate the droplets.

Concurrently, methods for collecting and analyzing droplets have also been developed and evaluated (Rathburn 1970, Beidler 1975, Peterson et al. 1978, Carroll and Bourg 1979). Several distances used in sampling aerosol clouds have also been reported (Mount 1970; Mount and Pierce 1972a, 1972b). Peterson et al. (1976) observed that the insecticide cloud breaks up at increasing distances and this inversely affects the volume mean diameter (VMD). In a separate study, consistent results for VMD were obtained at the 1.2 m distance (Peterson et al. 1978). However, the 7.6 m distance is required by the malathion label (Anonymous 1986).

Several investigators have reported that the settling chamber was the most accurate method of sampling droplets (Rathburn 1970, Mount and Pierce 1972a, Carroll and Bourg 1979). Their conclusions suggest that settling chambers may provide the most accurate estimate of the droplet spectrum at 1.2 m.

This work was conducted to compare 6 collection methods, to determine the distance suitable for collecting aerosol droplets, and to analyze an aerosol cloud produced by an electrically driven ULV cold aerosol generator (Whispermist 10, Beecomist Systems, Inc., Telford, PA) in regard to its capacity to generate a droplet spectra which conformed to the Malathion 91 (American Cyanamid) chemical label. The machine was calibrated for a Malathion 91 flow rate of 4.0 fl oz per min.

Six methods were used to sample the aerosol cloud:

1) Vertical swing. A Teflon® coated slide was held in an alligator clip mounted on the end of a 1.2 m long dowel rod. The dowel, with the slide facing the insecticide source, was then waved once through the aerosol cloud in a vertical top to bottom motion.

2) Complete diagonal swing. This method was performed with the same device as the vertical swing. However, the swing was in a diagonal direction toward the aerosol source starting at 0.61 m above ground level and up and through the cloud.

3) Top diagonal swing. This method was performed using the same device as 1 and 2 above. The swing was in a diagonal direction toward the aerosol source starting at 1.8 m above ground level and swinging up through the upper ⅓ to ¼ of the aerosol cloud.

4) Impinger. A battery powered motor was used to rotate a slide through the aerosol cloud (Carroll and Bourg 1979). The impinger was allowed to collect droplets for 5 min and then the slide was removed.

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[1] The opinions and assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department, the Naval Service at large or the USDA-ARS.

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5) Pendulum. A gravity driven device was used to swing the slide perpendicularly through the aerosol cloud (Beidler 1975).

6) Settling chamber. Five 6.4 mm plywood chambers, 0.46 × 0.46 × 0.46 m, were arranged adjacent to one another on a 0.8 m high table. Ten slides were placed on each of the chamber floors in an equally spaced and crossed (X) manner. However, only 3 slides containing sufficient drops were selected for analysis. A vehicle, mounted with a test machine, was then driven at 5 mph parallel to and 1.2 m upwind from the chambers. Immediately after passage of the aerosol cloud, chamber doors were closed. A chamber was opened at 0, 6, 12, 18 and 24 h, respectively, and the slides removed for droplet analysis.

Aerosol droplets were collected on Teflon® coated glass slides. Each slide was sealed in a slide box after sampling and read within 3 h. If a slide could not be read during that time it was covered with a paper gasket, an additional plain glass slide and taped to prevent evaporation. Droplet measurements were then performed within 24 h.

Samples were collected under the following environmental conditions: RH 60–80%, wind speed 2 mph with gusts to 6 mph, ambient temperature 23.9–27.2°C. The ULV generator was stationary during all collections, excluding the settling chamber. A randomized complete block design was used with 3 replications (1 slide per sample = 1 replication) for the first 4 methods described above at 1.2, 3.0 and 7.6 m. The settling chamber and pendulum were compared with the first 4 methods only at the 1.2 m distance. One hundred droplets on each slide were measured with a compound microscope. The measurements were then subjected to a ULV droplet analysis program (ULVDROPS Software Program, Haile et al. 1987). The corresponding volume median diameters (VMD) and percents in the 6–18 μm, ≥24 μm, >32 μm and ≥48 μm ranges were then analyzed by ANOVA (SAS User's Guide 1982 ed., pp. 139–199). The percent variability was calculated between the low and high VMD reading for each method and distance by simple percent method. Volume mean diameter and droplet range requirements are outlined on the American Cyanamid label and literature for Malathion 91 (Anonymous 1986).

Variability was high for each method within each distance as indicated by the standard deviations (Table 1). However, when methods were compared over distance, the complete diagonal method provided the most consistent results (2.4% variability). The impinger method produced a 4.5% variability. The pendulum swing was the least consistent method, yielding a 22.3% variability. There were no significant differences in the settling chamber results at 0, 6, 12, 18, or 24 h.

There were no significant differences with respect to VMD among the complete diagonal swing, impinger, top diagonal swing and vertical swing ($P = 0.206$) or distances ($P = 0.304$). There were also no significant differences when those 4 methods were compared with the settling chamber and pendulum swing ($P = 0.745$) at the 1.2 m distance. Since our analysis indicated no difference between the times used with the settling chamber, the VMDs were averaged over the 24 h period. Evans et al. (1975) also reported no significant differences between hand wave techniques and settling chambers when comparing VMDs. They further indicated that settling chamber size had no effect on VMD. In addition, our data indicate that label specifications were not met for this electric ULV generator (Table 1). Droplets greater than 48 μm were collected in all samples.

The small percent variability in VMD also suggests that the complete diagonal method may be the most consistent method of sampling aerosol clouds at any distance.

Table 1. Comparison of VMDs (μm ± SD) for 6 sampling methods used in collecting aerosol cloud droplets.

Sampling method	Distance (m) 1.2	3.0	7.6	% variability over distance
Complete diagonal swing	21.3[1] ± 6.9	20.8 ± 7.5	21.0 ± 6.8	2.4
Impinger	24.5 ± 4.5	23.5 ± 3.8	23.4 ± 0.9	4.5
Top diagonal swing	22.4 ± 6.9	19.7 ± 5.4	22.9 ± 13.7	13.9
Vertical swing	22.4 ± 6.9	21.1 ± 5.4	24.6 ± 8.7	14.2
Settling chamber	26.1[1]	—	—	6.0[2]
Pendulum swing	20.2[1]	—	—	22.3[3]

[1] Means of 3 replications (100 drops per slide = 1 replication). Settling chamber averaged over the 0, 6, 12, 18 and 24 h time periods.

[2] Percent variability between the settling chamber and impinger.

[3] Percent variability between pendulum swing and impinger.

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