DROPLET SIZE OF ULTRALOW VOLUME GROUND AEROSOLS AS DETERMINED BY THREE COLLECTION METHODS[1]

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ABSTRACT. The droplet sizes of ultralow volume ground aerosols were determined by hand wave, settling, and impaction collection methods. Mass median diameters (mmd's) and mass distribution data indicated only slight differences among the three methods. However, the number distribution and average diameter data showed that the hand wave method had a low degree of efficiency of deposit for aerosol droplets of less than 10 μ in diameter.

Because of convenience and simplicity, we have used the hand wave method of collecting aerosol droplets on glass microscope slides (Mount *et al.*, 1968; Mount *et al.*, 1970; Mount and Pierce (in press)). The prinicipal disadvantage of the hand wave method is that the efficiency of collection of small droplets ($<10\ \mu$) is poor; consequently, mathematical compensation has to be made for the decrease in the rate of deposition as the droplet size decreases. Therefore, we have evaluated settling and impaction as two alternate methods for determining droplet size of ultralow volume aerosols. The paper compares all three methods of droplet collection.

DROPLET COLLECTION PROCEDURES

Aerosol droplets of two insecticides, malathion and chlorpyrifos, and one diluent, soybean oil, were produced by a Leco® ULV (Model HD) cold aerosol generator.

All droplets were collected on silicone-treated (Dri-Film SC-87) glass microscope slides. The procedures used with each collection method were as follows.

HAND WAVE. The glass slides were attached to one end of a 2-foot section of aluminum pipe (1 inch O.D.) and waved rapidly through the aerosol blast at 3–6 feet from the nozzle. Three slides were waved through each ULV aerosol. One-hundred droplets were measured from each glass slide, thus making a total of 300 droplets. Mass median diameters (mmd's) were calculated on the basis of the droplet diameters, which according to Yeomans (1949) compensates for the decrease in the rate of impingement as the droplet size decreases.

SETTLING. A small plywood chamber (8 x 8 x 8 ft.) lined with a film of polyethylene was used as a confined atmosphere for settling of the aerosol droplets onto five glass slides that were placed on the floor prior to entry of the aerosols. The aerosols were blasted into the building by moving the aerosol generator slowly past an open door which was closed quickly to prevent loss of the droplets. The building was left sealed for 24 hours to allow time for the droplets to settle to the floor. Glass slides placed in the building for a second 24-hour period (24–48 hours posttreatment) showed that no additional droplets settled to the floor.

With the settling method, we assumed that all of the different sizes of aerosol droplets would be represented in their true proportions; therefore, the mmd's were determined on the basis of the volume of each droplet sampled. A minimum of 200 droplets was sampled for each aerosol.

[1] This paper reflects the results of research only. Mention of a pesticide or a commercial or proprietary product in this paper does not constitute a recommendation or an endorsement of this product by the U. S. Department of Agriculture.

IMPACTION. A Staplex® Model BN low volume air sampler was utilized for impaction of the ULV aerosol droplets. The droplets were impinged on glass slides at each of the four progressively smaller collection jets located on the sides of the impactor. The air sampler was regulated at an air intake of 12 liters per minute during the collections. The aerosols were sampled at a distance of approximately 12 feet from the nozzle of the generator. Untreated air samples were also taken to obtain a background count of fine dust and other inert particles.

With the impaction method, the determination of mmd's involves a much more complex procedure than is required for either the hand wave or settling methods. The procedure requires estimation of the number of droplets for each band of droplets deposited on the glass slides. This was done by measuring the length and width of each band and by counting the number of droplets per traverse of known width across the width of the deposit bands. A minimum of three traverses was taken across each band. After this had been done, 100 droplets were measured from each band to determine droplet size frequencies. Droplet densities and size frequencies were then combined to obtain the number of each size for all four deposit bands. Because of the high degree of efficiency of deposit for aerosol droplets with the impaction method, the mmd's were determined on the basis of the volume of each droplet.

SPREAD FACTORS. A direct measurement method similar to one reported by Anderson and Schulte (1971) was utilized to determine the spread factors of the aerosol droplets on the silicone treated glass slides. The base diameter and height of the impinged droplets were viewed from the side at 450X magnification and measured with an ocular micrometer. Slides on which a dense sample of droplets had been obtained were oriented so that one edge could be viewed with a microscope.

Once the base diameter and height of an impinged droplet were measured, the volume of that droplet was computed from a geometric formula for the volume of a spherical segment [$1/6\ \pi$ height (height^2 + 3 radius^2)]. Next, the diameter of a spherical droplet containing the same amount of liquid was calculated from the formula for the volume of a sphere ($4/3\ \pi$ radius^3). The last step in obtaining the spread factor was to divide the original sphere diameter by the observed diameter of the impinged droplet.

Spread factors were as follows: soybean oil (0.57), malathion (0.51) and chlorpyrifos (0.49).

RESULTS AND DISCUSSION

The mass distribution and mmd data (Table 1) indicated only slight differences in droplet sizes with the three collection methods used. The largest difference obtained was for soybean oil which gave a mmd of 19 μ for the impaction method as compared to mmd's of 24 μ and 26 μ for the settling and hand wave methods, respectively. Similarly, a slight difference was also noted for malathion with a flow rate of 1.5 fl oz per minute at 2.5 pounds per square inch (19 μ mmd for impaction vs 22 μ and 23 μ mmd for hand waving and settling, respectively). All of the other comparative mmd's were essentially the same.

The number distribution and average diameter data (Table 2) for malathion and chlorpyrifos showed clearly that the hand wave method yielded samples highly biased for droplets over 10 μ in diameter. Therefore, the true average droplet diameters were obtained only by the settling and impaction collection methods (an average of 3.35 μ for malathion and 2.8 μ for chlorpyrifos). The average droplet diameters indicated for the hand wave collections were invalid.

Our results with the three methods of droplet collection suggested that each of them could be used advantageously, depending on the amount of testing to be done and materials that are readily obtainable. The hand wave method is the

TABLE 1.—Mass distribution and mass median diameter of ultralow volume ground aerosols.

Collection method	Percentage of total mass in indicated range of droplet size (μ)					Mass median diameter (μ)
	<5	5–10	11–20	21–40	>40	
			Soybean oil (3 fl. oz./min. at 4.5 psi)			
Hand wave	1	3	20	64	12	26
Settling	3	9	21	67	0	24
Impaction	6	14	35	45	0	19
			Malathion (3 fl. oz./min. at 4 psi)			
Hand wave	3	14	47	35	1	18
Settling	7	18	55	20	0	16
Impaction	7	14	53	25	0	17
			Malathion (1.5 fl. oz./min. at 2.5 psi)			
Hand wave	2	7	38	49	3	22
Settling	1	3	19	53	23	23
Impaction	3	13	47	37	0	19
			Chlorpyrifos (3.2 fl. oz./min. at 4 psi)			
Hand wave	12	38	47	3	0	10
Settling	10	40	50	0	0	10
			Chlorpyrifos (3.2 fl. oz./min. at 1.5 psi)			
Hand wave	4	18	45	33	0	17
Settling	2	7	58	33	0	18

TABLE 2.—Number distribution and average diameter of ultralow volume ground aerosols.

Collection method	Percentage of total number of droplets in indicated range of size (μ)				Average diameter (μ)
	<5	5–10	11–20	21–40	
		Malathion (3 fl. oz./min. at 4 psi)			
Hand wave	9	23	47	21	15.4 [a]
Settling	83	11	5	1	3.8
Impaction	94	3	2	1	2.9
		Chlorpyrifos (3.2 fl. oz./min. at 4 psi)			
Hand wave	37	41	21	1	7.9 [a]
Settling	85	12	3	0	2.8

[a] Invalid.

quickest and most convenient to use, but the biased droplet samples obtained must be weighted to give a valid estimate of the mmd. The settling method has the definite advantage of yielding collections that represent all droplet sizes in their true proportions; however, the use of a confined atmosphere limits the amount of testing which can be done. Furthermore, a confined atmosphere (air-tight building) would not be readily available for some workers desiring to obtain estimates of droplet size. The impaction method combines several of the best features of the other two methods since it is convenient to use and yields an unbiased droplet sample. The main disadvantage of the impaction method is that additional measurements and calculations must be made to determine the total number of droplets impinged at each collection jet. These steps are time consuming and, therefore,

tend to limit the amount of droplet size testing which can be done.

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SIMPLE BIOLOGICAL AND CHEMICAL METHODS TO DETERMINE THE CALORIC RESERVES OF MOSQUITOES

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ABSTRACT. Two methods are described to determine the caloric contents of mosquitoes. The biological method depends on accumulative mortality in a non-fed population. The chemical method depends on complete oxidation of the mosquito with bichromate and spectrophotometric assay of reduced chromium.

The ability of a mosquito to survive, and therefore, to transmit disease depends largely on its caloric reserves. The two endogenous sources of fuel, fat and glycogen, disappear during starvation, and reappear after feeding on sugar or blood (Van Handel, 1965). In addition, the nature of the fuel used during sustained tethered flight has been determined (Nayar and Van Handel, 1971). The determination of fat and glycogen requires considerable effort and the usual "fat" and "glycogen" measurements include a fair amount of structural material that is not available as a caloric source. Moreover, when a mosquito has taken a nectar meal shortly before capture and is then maintained without further food, its glycogen and fat reserves will initially increase instead of decrease. Thus, these determinations do not necessarily show the total caloric energy available for activity. Two methods which do not show this defect have been developed.

SURVIVAL TIME WITHOUT FOOD. When mosquitoes are held at constant temperature in a clean plastic cage with only water available in a near-saturated atmosphere, the 50 percent mortality time is an accurate measure for biologically available reserves (Fig. 1), irrespective of the nature of these reserves. The biological method, however, requires fairly large numbers (50–100 mosquitoes per determination) and considerable surveillance, because dead mosquitoes have to be counted at frequent intervals in order to accurately establish the 50 percent mortality time. I have therefore made an attempt to supplement the biological method with a chemical method, requiring only a single reagent and minimal manipulation.

DETERMINATION OF BICHROMATE VALUES. An acid solution of bichromate oxidizes the entire mosquito, including protein, lipids, carbohydrates and chitin to CO_2, while reducing the red Cr^{VI} to the green Cr^{III} ion.