Department of Pesticide Regulation

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MEMORANDUM

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SUBJECT: SUMMARY OF INDOOR AIR MONITORING FOR SULFURYL FLUORIDE STRUCTURAL FUMIGATIONS

INTRODUCTION

From September 2014 through March 2015, the Environmental Monitoring Branch (EM) of the Department of Pesticide Regulation (DPR) has monitored 23 sulfuryl fluoride structural fumigations statewide to determine the distribution of the mass loss during the fumigation treatment period. During the monitoring, the hourly indoor concentrations of sulfuryl fluoride are also collected to calculate the standardized hourly flux of the treatment period. The hourly flux is the input of the air dispersion modeling to estimate sulfuryl fluoride concentrations around a fumigated house. The mass loss distribution and modeling results will be used to develop mitigation measures for sulfuryl fluoride use in structural fumigation.

The air monitoring was conducted using a Remote Data Acquisition (RDA) Fumiscope. The RDA Fumiscope uses the same methods of analysis as the basic Fumiscope, which draws air through intake tubes from inside and outside of a fumigated structure and measures sulfuryl fluoride concentration by comparing the thermal conductivity of the sampled indoor air and that of the ambient air. The RDA provides instantaneous, real-time readings of the sulfuryl fluoride indoor concentration (oz/1000 ft^3) from up to 4 intake locations every hour. In addition, the readings can be accessed remotely via computer with internet connection.

All 23 monitored fumigations used Vikane® gas fumigant (100% sulfuryl fluoride) of the Dow AgroChemical Company. Besides RDA readings, DPR staff documented fumigation information from each application including the date and time of fumigation, aeration, and tarp removal, the applied amount of sulfuryl fluoride, Vikane® calculator inputs used to decide the dosage, and calculator estimate of half loss time (HLT). Visual observations of the neighborhood, house floor plan, tarp condition, and seal condition were also recorded.

DATA PROCESS

The RDA Fumiscope was placed in a central location of the house and four intake tubes were connected to the equipment and extended to the chosen monitoring locations. To measure evenly distributed concentrations, the monitoring sites were chosen to be in the rooms away from the fumigant introduction area. The intake tube ends were taped to the wall or furniture at least 3 feet above the floor of the chosen monitored rooms.

The average concentrations of the four sampled locations are used to calculate the mass loss and the HLT of the treatment period. If the mass loss reached or exceeded 50% of the applied amount during the treatment period, the HLT is the time when the concentration was measured at 50% of the initial concentration. If the mass loss was lower than 50% at the end of the treatment period, the measured indoor concentrations and the hours when the concentrations were measured were used to fit a log-linear regression model:

$$\ln(\mathrm{C_T}) = \mathrm{aT} + \mathrm{b}$$

Where C_T is the indoor concentration measured at hour T; T is the elapsed hour since the equilibrium level is reached; *a* is the slope of the regression; and *b* is the intercept. The time when the indoor concentration reached half of the equilibrium concentration (C_1) was then estimated with the fitted *a* and *b* as the measured HLT:

$$HLT = \frac{ln\left(\frac{C_1}{2}\right) - b}{a}$$

The applied amount of sulfuryl fluoride is divided by the average equilibrium concentration to estimate the fumigation volume of a tarped structure. The differences between the estimated volume and the volume calculated by the applicators ranged from -32% to 27% (Table 1). In the field notes, DPR staff recorded that every house had very different sizes, shapes, and floor plans; and there were various types and sizes of attached exterior structures (e.g. patio, storage), which had to be tarped and fumigated with the main structure (Figure 1). These issues existing in common residential houses make it difficult to estimate the structure volume before the fumigation.

The footprint area of a fumigated structure is approximately estimated from the house information recorded by DPR staff, satellite images on Google Earth, and the property description and sale pictures listed online at real estate websites. The structure height is then calculated from the estimated fumigation volume and area.

DATA SUMMARY

Table 2 summarizes house information, estimated HLT, and mass loss of the 23 monitored fumigations. The estimated fumigation volumes ranged from 19,200 to 71,400 ft^3 (Figure 2). Most of the fumigations were between 25,000 and 50,000 ft^3. The application rates were measured from 0.38 to 1.14 lbs/1000 ft^3 with the median at 0.61 lbs/1000 ft^3 (Figure 2).

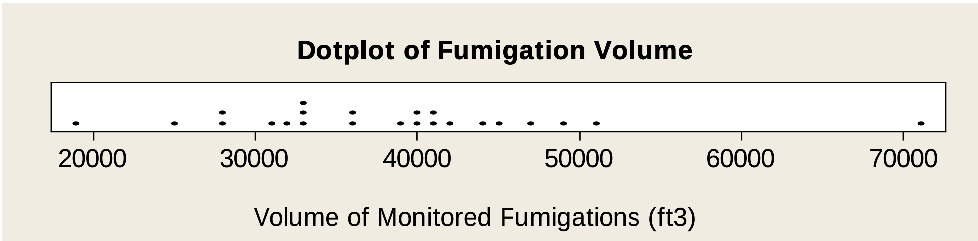
The HLTs estimated before applications by the Vikane® calculator ranged from 16 to 34 hr. Compared to the calculator HLTs, the measured HLTs had a larger range and spread from 11 to 60 hr (Figure 2). There was no significant relationship between the values of these two HLTs for each house. In the field observations, DPR staff noted several factors that could contribute to mass loss, such as tarp conditions (e.g. multiple holes, cuts, and patches) and seal conditions (e.g. Figure 1, attached large-size exterior structures compromising seal condition). However, none of these factors can be quantified to relate with the mass loss. In addition, although the calculator considers the effect of environmental factors on the mass loss, these factors such as wind speed, temperature, and humidity, are changing over time and only their estimates at the moment of application can be taken by the calculator. Therefore, the calculator may work as a practical tool for applicators to determine the application amount of a fumigation job but cannot accurately predict the HLT. To obtain the mass loss information and the actual HLT of a fumigated house, air monitoring equipment such as RDA Fumiscope is necessary.

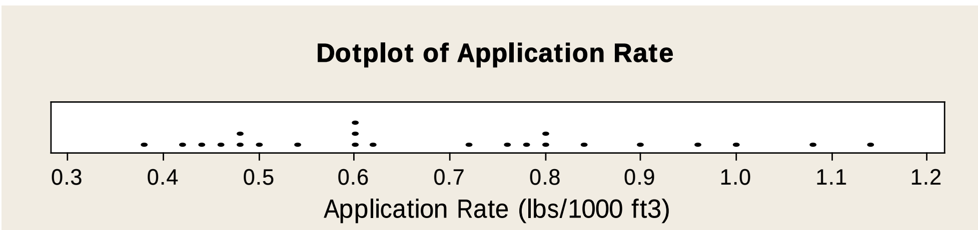
The mass loss percentages during treatment periods were estimated from 22 to 81% and showed a normal distribution with a mean of 50% (Figure 3). Meanwhile, RDA measurements of 10 fumigations conducted in San Luis Obispo County were provided to DPR by a termite treatment company. The applicator monitored these fumigations using their own RDA and sent DPR the equilibrium and terminal concentrations of the treatment periods. The mass loss percentages calculated from these data showed a similar range with a higher mean (Figure 3). There are no significant relationships between mass loss percentages and fumigation volumes, application rates, house areas, and heights (Figure 4). Although the four structures with the highest mass loss percentages were unfurnished houses, overall there is no significant difference between mass loss of furnished and unfurnished houses (Figure 5).

CONCLUSION

The air monitoring study for 23 structural fumigations showed considerable variability of HLT (11 – 60 hr) and mass loss (22 – 81%) during the fumigation treatment period. Due to the complexity and individuality of residential structures, it is challenging for applicators to estimate the accurate fumigation volume. Because of the rough estimate of the volume and environmental conditions, the actual application rates for the same pest treatment differ from house to house. According to field observations, tarp and seal conditions may have noticeable impacts on the mass loss of the fumigation treatment period, although the magnitude of these impacts cannot be quantitatively evaluated with the current data.

Figure 1. Examples of house exterior structures in high-density single-family housing areas. Exterior structure attached to the main house had to be tarped. However, maintaining a quality seal around fencing can be challenging.





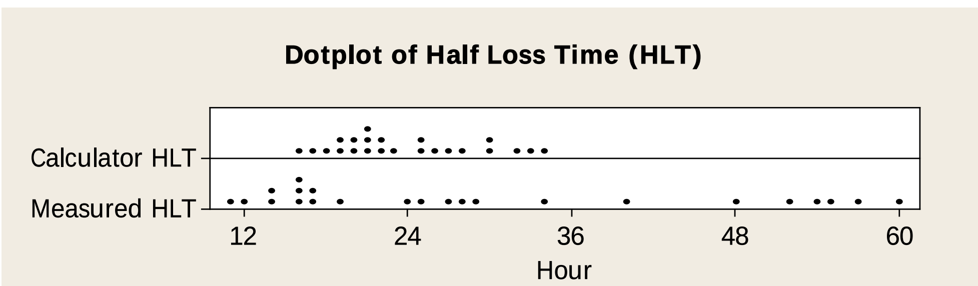


Figure 2. Distributions of volume, application Rate, and Half Loss Time (HLT) of monitored fumigations.

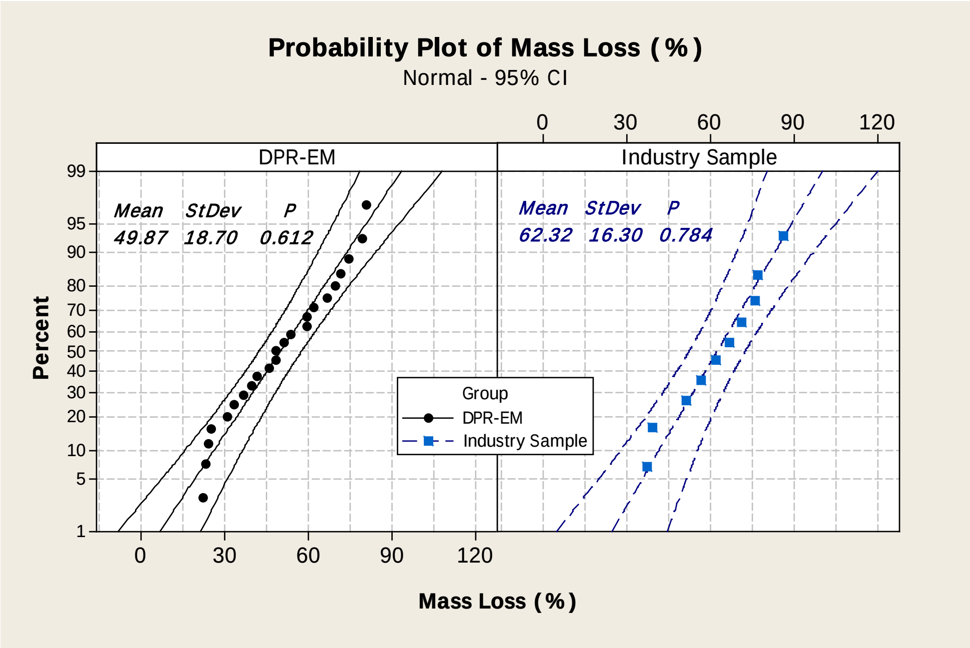


Figure 3. Distributions of mass loss percentages during treatment periods of Monitored Fumigations.

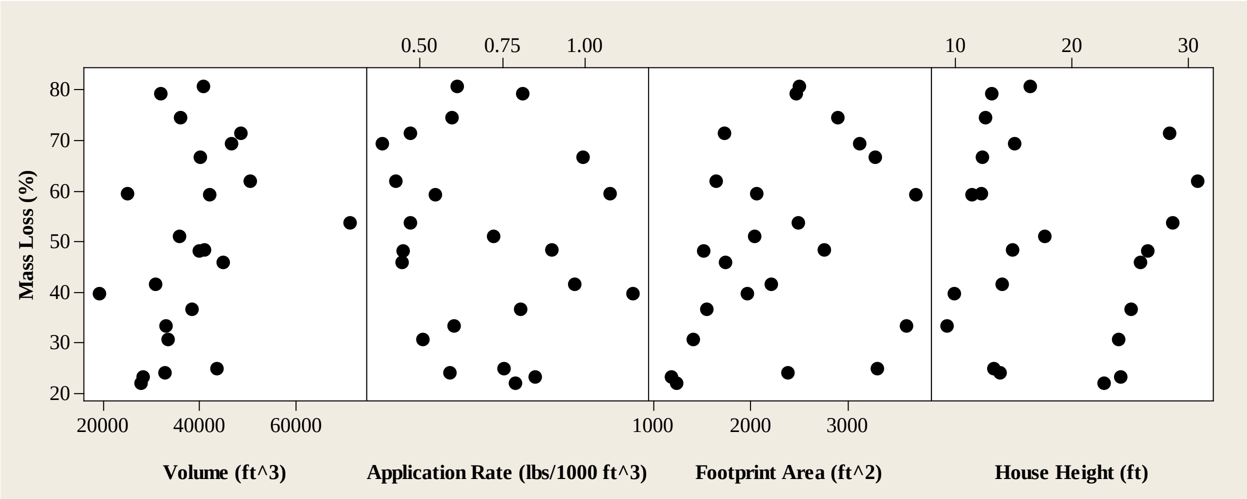


Figure 4. Comparison of mass loss percentages for the treatment period of fumigations at different volumes, application rate, house footprint area, and height.

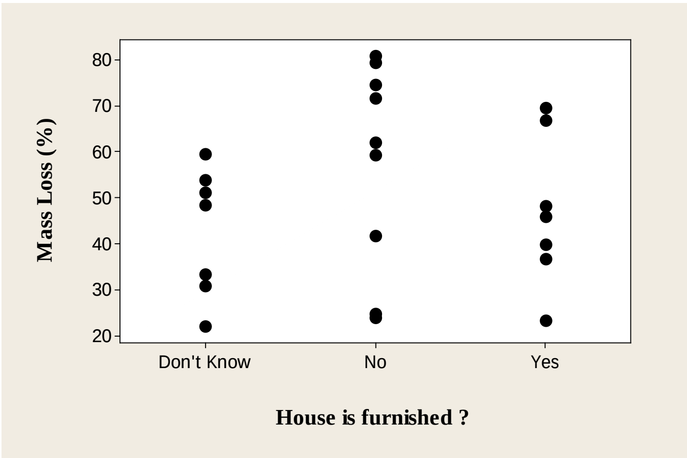


Figure 5. Comparison of mass loss percentages of furnished and unfurnished Houses.

Table 1. Comparison of the fumigation volumes provided by applicators and estimated from application amounts and concentration measurements.

House ID	Volume (ft^3)		Difference (%) (V2 – V1)/V1
	V1 provided by applicators	V2 estimated from measurements	
SC1	28000	19000	-32
SJ1	34000	25000	-26
SC4	41000	32000	-22
LA1	34000	28000	-18
ORG1	40000	33000	-18
SC6	52000	44000	-15
SAC3	36000	31000	-14
SC2	32000	28000	-13
LA3	39000	36000	-8
LA2	42000	40000	-5
MER1	43000	41000	-5
ORG4	44000	42000	-5
ALA2	38000	39000	3
SC5	35000	36000	3
ALA1	38000	40000	5
SAC1	48000	51000	6
ORG2	31000	33000	6
SC3	30000	33000	10
SAC2	64000	71000	11
SD1	38000	45000	18
ORG5	40000	49000	23
SAC4	33000	41000	24
ORG3	37000	47000	27

Table 2. Summary of monitored fumigations.

County	House ID	Calculator HLT (hr)	Measured HLT (hr)	Mass Loss (%)	Mass Loss (lbs)	Applied Amount (lbs)	Volume (ft^3)	Area (ft^2)	Height (ft)
Alameda	ALA1	20.6	14.2	66.7	26.7	40	40300	3280	12
Alameda	ALA2	21.8	39.5	36.7	11.4	31	38500	1540	25
Los Angeles	LA1	16	54.6	22.0	4.8	22	27900	1230	23
Los Angeles	LA2	33.9	25.1	48.3	8.7	18	40000	1510	26
Los Angeles	LA3	22	28.0	51.1	13.3	26	35900	2040	18
Merced	MER1	17.4	23.7	48.4	17.9	37	41100	2760	15
Orange	ORG1	27.4	59.6	33.3	6.7	20	33100	3600	9
Orange	ORG2	18.7	48.0	30.8	5.2	17	33500	1400	24
Orange	ORG3	29.6	14.3	69.5	12.5	18	46800	3120	15
Orange	ORG4	32.4	15.7	59.3	13.6	23	42200	3700	11
Orange	ORG5	33.3	15.5	71.5	16.5	23	48700	1720	28
Sacramento	SAC1	27.8	17.0	61.9	13.4	21.6	50600	1640	31
Sacramento	SAC2	26.3	18.6	53.8	18.1	33.6	71400	2490	29
Sacramento	SAC3	25	28.7	41.6	12.5	30	31000	2210	14
Sacramento	SAC4	20.9	11.6	80.8	20.2	25	40900	2500	16
San Diego	SD1	29.9	27.3	46.0	9.2	20	44900	1730	26
San Joaquin	SJ1	25	17.2	59.5	16.1	27	25100	2060	12
Santa Clara	SC1	20	34.0	39.7	8.7	22	19200	1960	10
Santa Clara	SC2	20.7	52.3	23.2	5.6	24	28300	1170	24
Santa Clara	SC3	18.6	54.2	24.0	4.7	19.4	32800	2380	14
Santa Clara	SC4	20.4	16.3	79.3	20.6	26	32100	2460	13
Santa Clara	SC5	18.2	11.1	74.6	16.1	21.6	36200	2900	13
Santa Clara	SC6	22.9	56.6	24.8	8.2	33	43700	3300	13
Median		**22**	**25.1**	**48.4**	**12.5**	**23**	**38500**	**2210**	**15**
Minimum		**16**	**11.1**	**22.0**	**4.7**	**17**	**19200**	**1170**	**9**
Maximum		**33.9**	**59.6**	**80.8**	**26.7**	**40**	**71400**	**3700**	**31**