CONCLUSIONS:

Mobility - Laboratory Volatility

This laboratory volatility study provides supplemental data. It cannot be used to fulfill the data requirement (163-2). These data were taken from published articles and were not originally designed to satisfy Subdivision N data requirements. Therefore, it is difficult to draw the conclusions needed for an environmental fate assessment. However, these data and other published volatility data submitted (MRID 40673601A, 40673601C, 40673601D, 40673601E, 40673601F, 40673601G) do indicate the following:

1. Volatility may be a major route of dissipation for trifluralin.
2. Trifluralin appears to volatilize (~25 to 60% of applied in 11 days).
3. Data are needed to determine relative rate of dissipation due to volatility in relation to other routes of dissipation.
In this study the concentration of trifluralin in air and soil was not determined or analyzed for or furnished. Therefore, the application rate and material balances could not be confirmed and the concentration of trifluralin residues in the air could not be related to the concentration of trifluralin residues in the soil. In addition, the pattern of decline of the test substance could not be established.

METHODOLOGY:

Laboratory volatility

In order to measure vapor density without soil, technical grade trifluralin (purity of 99.5%) dissolved in hexane was added to silica sand with an atomizer (4 g trifluralin:1100 g sand). The hexane was allowed to evaporate and the treated sand was placed in a glass column. Dry nitrogen gas was passed through the trifluralin-treated sand at 3.5 mL/min and through a hexane trapping solution "until sufficient trifluralin had been trapped...for analysis". The hexane solution was analyzed by GLC with electron capture detection.

To measure the effects of trifluralin concentration and moisture content on vapor density, autoclaved silt loam soil (Gila; 18.4% clay and 0.58% organic matter, not further characterized) was treated with trifluralin (technical grade; purity 99.5%) at 2.5-80 µg/g. After the hexane evaporated, the soil moisture was adjusted with water (for water content <6%) or ice (for water contents >6%). The method used to determine the vapor density was not reported.

To determine the effects of organic matter on volatilization, the vapor density of trifluralin was measured in clay soil (Imperial; 68% clay, 0.20% organic matter, not further characterized), Gila silt loam soil, and sandy loam soil (Kentwood; 10.0% clay, 1.62% organic matter, not further characterized). The soil moisture was adjusted to 19% water content and the trifluralin (technical grade; purity 99.5%) concentration was 10.0 µg/g. Columns of soil were prepared and allowed to equilibrate to varying moisture contents for 24 hours prior to vapor density measurements. The method used to determine the vapor density was not reported. The moisture and trifluralin content of soils were measured at the beginning and end of each series of vapor density measurements (method not reported).

To study the volatilization of trifluralin incorporated into the soil, trifluralin (technical grade; purity 99.5%) in hexane was added to autoclaved silt loam soil (Gila) at 10 µg/g. The soil was placed in a column (10 cm length, 4.78 cm id). Nitrogen gas was passed over the surface of soil columns at 809 mL/min; the atmosphere in the headspace was replaced approximately every 3 seconds. The water content of the soil in the columns was 30.5%, the nitrogen gas was adjusted from 100% relative humidity at the start of the study to 0% at the termination. The nitrogen was vented through a hexane or
ethylene glycol trapping solution. The experiment was conducted for up to 48 days. The method used to determine the vapor density was not reported.

To study the volatilization of trifluralin from the surface of the soil, trifluralin (technical grade; purity 99.5%) in hexane was added to the surface of columns of autoclaved silt loam soil (Gila) at 1, 2 and 10 kg/ha. Columns for surface application volatility testing were wetted from the bottom to 30.5% moisture content. The 2 kg/ha rate was also used to measure volatility at 50 and 100% relative humidity. The method used to determine the vapor density was not reported.

DATA SUMMARY:

Trifluralin (technical grade; purity 99.5%) dissolved in hexane, and incorporated into columns of autoclaved silt loam soil at 10 μg/g, volatilized slowly (half-life not calculated). Total loss for the first 24 hours was 0.0517 kg/ha (0.36% of total applied); total loss for 48 days was 0.342 kg/ha (2.45% of applied). Volatilization was greater at lower relative humidities. When trifluralin was applied to an air dry surface without incorporation, volatilization during the first hour was 0.0014 kg/ha; when application was to a wet surface, losses were 0.142 and 0.153 kg/ha; when the dry soil was wetted from the bottom, volatile loss was 1.97 kg/ha/day. When 1 and 2 kg/ha of trifluralin were applied to moist surface soils, the entire application was volatilized within 24 hours.

In sand, the vapor density of trifluralin (technical grade; purity 99.5%) at 4 g trifluralin:1100 g sand was 0.889 μg/L at 20°C, and was 19.94 μg/L at 40°C. The vapor pressure increased from $0.485 \times 10^{-4}$ mm to $11.59 \times 10^{-4}$ mm (Table 1).

COMMENTS:

1. EFGWB prefers that [14C]residues in samples be separated by chromatographic methods (such as TLC, HPLC, and GC) solvent systems of different polarity, and that specific compounds isolated by chromatography be identified using a confirmatory method such as MS in addition to comparison to the $R_f$ of reference standards.

In this study aliquots of the extracts were analyzed by GLC only or not furnished. The analytical method did not measure the concentration of trifluralin in the carrier gas. Trifluralin was trapped, and the flux was measured as losses per acre.

2. Soil samples were not analyzed for trifluralin; therefore, the pattern of decline of trifluralin from the soil could not be measured, the application rate was not confirmed, and the concentration of
trifluralin in the air could not be related to the amount of trifluralin in the soil.

3. Material balance data were not included.

4. The methods description was inadequate; for example, the incubation conditions and temperature were not reported.

5. The presentation of the data was not clear enough to permit an accurate assessment.

6. Soils used in this study were not completely characterized.

7. The efficiencies of the trapping solutions were not reported.

8. The study author stated that the 10 µg/g application rate used in the incorporation study was equivalent to 14 kg/ha.

9. This study is one of several published papers included as appendices to MRID 40673601 (Day, E.W. 1988. Laboratory and field volatility studies with trifluralin from soil. Laboratory Project ID. EWD8807). This document was submitted as an assessment of the potential inhalation hazard of trifluralin to exposed workers. Because this portion of the document contains summary data only and is not pertinent to Subdivision N guidelines, it was not reviewed; only the published papers in the appendices have been reviewed.
STUDY AUTHOR(S)'S RESULTS AND/OR CONCLUSIONS

(INCLUDING PERTINENT TABLES AND FIGURES)
Table 1. Vapor Density and Apparent Vapor Pressure of Trifluralin at Different Temperatures

<table>
<thead>
<tr>
<th>Temp, °C</th>
<th>Vapor density, ng/l</th>
<th>Vapor pressure, mm Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.889 ± 0.016</td>
<td>0.495 ± 0.009</td>
</tr>
<tr>
<td>30</td>
<td>4.29 ± 0.09</td>
<td>2.42 ± 0.05</td>
</tr>
<tr>
<td>40</td>
<td>19.94 ± 0.30</td>
<td>11.69 ± 0.17</td>
</tr>
</tbody>
</table>

*Calculated from vapor density (ρ) with the equation P = ρRT/μ, where P is the vapor pressure, ρ is the molar mass constant, T is the absolute temperature, and μ is the molecular weight.

![Graph showing vapor density of trifluralin as related to concentration in Gila soil at 6 and 18% soil water contents and 30°C. The asterisk indicates vapor density of trifluralin without soil.](image)

Figure 1. Vapor density of trifluralin as related to concentration in Gila soil at 6 and 18% soil water contents and 30°C. The asterisk indicates vapor density of trifluralin without soil.

The data reported here are based on the trifluralin concentrations and soil water contents measured rather than the amounts supposedly applied. Vapor density increased rapidly as trifluralin concentration increased, and at 15% water a saturated vapor density equal to that of trifluralin without soil was reached at approximately 73 μg/l. For a saturated vapor at 15% water, the projected trifluralin concentration reached was approximately 95 μg/l. Obviously, the volatile of trifluralin would be greater at 15% than at 6% soil water content. For example, at 10 μg/l the vapor density is 30% greater at 15% than at 6% soil water content.

Figure 3 shows the effect of a wider range of soil water contents on trifluralin vapor density at two trifluralin concentrations. Vapor density was markedly reduced in the lower soil at both trifluralin soil concentrations (6 and 12 ng/l), but the vapor density began to decrease at a higher soil water percentage at 6 μg/l than at 12 μg/l. When the soil water content reached 6%, the vapor density at both trifluralin concentrations was significantly reduced. Air drying the Gila silt loam to approximately 7% water content reduced the vapor density to extremely low values. For example, at soil trifluralin concentration of 2.155 μg/l, the vapor density in air-dry soil ranged only from 0.31 to 0.65 μg/l. At 1% soil water content, the trifluralin vapor density, or potential volatility, was 3000-5000 times greater than when the soil was air dry. As the soil water content was reduced, trifluralin vapor density began to decrease at a higher soil water content than observed for dichloro or lindane. Vapor densities of dichloro at 100 μg/l (Spence et al., 1968) or lindane at 10 μg/l (Spence and Cash, 1970b) in Gila silt loam did not decrease until the soil water content was reduced below approximately...
one molecular layer of water equivalent in approximate 2.1% water in Gila salt loam.

Vapor densities at 10 μg/g of triliruan in three soils varying in organic matter (0.08-0.31%) were 3.19, 1.38, and 0.62 μg/g. In Imperial clay 10.8% (O.M.I.), Gila salt loam 5.06% (O.M.I.), and Renwood sand 11.6% (O.M.I.), respectively. Thus, vapor density decreased as O.M. content increased. Since the clay content was increased in the G.M. content of the three soils, the results indicate that clay plays a minor role in triliruan adsorption in wet soil. Evidence of triliruan adsorption, consequently vapor density, or potential volatility, is a function of the O.M. content of the soil at least in wet soils. Spencer (1929) reported that vapor densities of deodaran was inversely related to the O.M. content of the same three soils.

The decreasing vapor density of triliruan with increasing soil O.M. content is consistent with data reported by other workers. Morse et al. (1971) reported that the transmittance and persistence of triliruan in four soils were related to the O.M. content of the soils. Sugawara et al. (1971) found that in 21 soils the total carbon content of the soil was highly associated with triliruan activity--51% of the variability in root-to-triliruan could be accounted for by total carbon content of the soil, whereas only 35% of the variability was associated with clay content.

Volatilization of Triliruan from Soil. The volatilization rate of soil-incorporated triliruan as a function of time and water loss rate over a 60-day period is shown in Figure 2. The maximum volatilization rate during the first 15 min was 4.19 μg/cm² per day. This decreased to less than 0.20 μg/cm² per day within 24 hr. The total loss for the first 24 hr was 0.30 μg/cm² or 0.11% of that applied. The total loss by volatilization during the 48-day period was 0.32 μg/cm² (3.04 μg/kg-ha) or only 2.43% of that applied. The rapid decrease in volatilization rate of soil-incorporated triliruan with time was also observed with deodaran and deodaran (Spencer and Claght, 1973). The decrease in volatilization of soil-incorporated triliruan was caused by deposition of triliruan at the soil surface and not by anaerobic degradation of triliruan in the soil as reported by Parr and Smith (1973). The Gila salt loam was unstable which effectively retarded microbial degradation during the test period.

Volatilization rates were somewhat higher at the lower relative humidities, indicating that evaporating water slightly increased the volatilization rate of triliruan by the effect of transporting triliruan to the surface in evaporating water. This was most apparent at 5% and 0% relative humidity when water was evaporating at the higher rates, compared to no water loss at 10% relative humidity. The effect of evaporating water on the loss of triliruan was not nearly as great as was observed with limedans (Spencer and Claght, 1973). At 10% relative humidity, the triliruan volatilization rate leveled off at flux values approaching 0.05 μg/cm² per day (0.003 kg/ha per day). When a period of 100% relative humidity followed a drying period at 0 or 50% relative humidity, the volatilization rate of triliruan did not increase as did that of deodaran (Spencer and Claght, 1973). This indicates that triliruan volatilized from the surface at approximately the same rate as it moved upward in the evaporating water and, unlike deodaran, did not accumulate at the surface during drying.

Triliruan volatilized much more rapidly when applied on the soil surface than when stirred into the soil. Figure 3 shows volatilization of triliruan applied on the wet surface of Gila salt loam at the rate of 1, 2, and 10 kg/ha with the N₂ gas passing over the soil surface at 100% relative humidity. Initially, volatilization was almost the same for all three application rates, but volatilization for the 1- and 2 kg/ha applications decreased much more rapidly than for 10 kg/ha with time due to more rapid surface depletion. The maximum volatilization rate from each surface treatment was approximately 0.50 μg/cm² per day (4 kg/ha per day) compared with a volatilization rate of 0.017 kg/ha per day for the first 24 hr after soil incorporation.

With surface applications, the volatilization rate during the initial period of measurements (either 15 or 30 min) was lower than that measured during the second or third volatilization period. This was probably caused by a reduced triliruan vapor pressure in the presence of moisture before its complete evaporation during the first few minutes of measurement.

Figure 4 shows volatilization rates of surface applied triliruan at 2 kg/ha when applied (a) to a wet soil with the N₂ gas at 100% relative humidity, (b) to a retted with the N₂ gas at 50% relative humidity, and (c) to an adn-dried soil which was watered after 8 to 9 hr at volatilization. With the wet soil surface, passing 50% and 100% relative humidity, no soil resulted in no significant differ-
The high volatilization rates from surface applications indicate that vapor loss is the major reason for the lack of herbicidal activity from surface applications, but does not rule out the possibility of photolysis of trfluuralin or other herbicides, since these factors can account for a significant portion of the overall degradation of these compounds in the field. The natural relation between volatilization rates measured in laboratory columns and those expected in the field is unknown. In the field, volatilization rates from surface applications probably would be higher than those reported here because of higher rates of air exchange and more soil conditions. The gas over the soil surface was exchanged on the average, once every 3 sec which is equivalent to a linear flow rate of only 0.625 m/sec. This is relatively low compared to airspeeds encountered in most agricultural areas. Consequently, for a well mixed, maximum volatilization rate of surface-applied trfluuralin (approximately 4 kg/ha per day) is probably below the maximum rates that would occur under many field conditions. However, volatilization rates from field-applied rates of trfluuralin in the field probably would be similar to those reported here since the rate of loss would be controlled by the rate of trfluuralin movement into the soil surface by the rate of air exchange over the soil surface.

High volatilization rates, such as those observed from surface applications of trfluuralin, are evidenced by the fact that most pesticides, but at differing rates depending on the local meteorological conditions. Many pesticides applied to foliage and non-herbicidal surfaces have vapor pressures similar to trfluuralin; therefore, similar volatilization rates can be expected. Such high rates of volatilization contribute to the short-term effectiveness of many herbicides, the low use-efficiency of some herbicides, and the environmental contamination with pesticides.

LITERATURE CITED

Hartley, H. L., Proc. 9th Int. Conf. on Soil Sci., 95, 1953.
Porter, L. J., and Weiler, J. C., in Proc. 9th Int. Conf. on Soil Sci., 95, 1953.
Rice, G. C., and Weiler, J. C., in Proc. 9th Int. Conf. on Soil Sci., 95, 1953.
Sorensen, H. J., and Weiler, J. C., in Proc. 9th Int. Conf. on Soil Sci., 95, 1953.