LITERATURE CITED

Allen, A. M., Smith, J. T., *Am. Chem. Soc. Abstr.* 1, 166 (1976).
Allen, A. M., Smith, J. T., *Tenn. Farm Home Sci. Prog. Rep.* **103**, 15 (1977).
Allen, A. M., Smith, J. T., *Fed. Proc., Fed. Am. Soc. Exp. Bio.* **37**, 848 (1978).
Bell, R. N., Audrieth, L. F., Hill, O. F., *Ind. Eng. Chem.* **44**, 568 (1952).
Caputto, R., McCay, R. B., Carpenter, M. P., *J. Biol. Chem.* **233**, 1025 (1958).
Carroll, N. V., Longley, R. W., Roe, J. H., *J. Biol. Chem.* **220**, 583 (1956).
Crowther, J., Westman, A. E. R., *Can. J. Chem.* **34**, 969 (1956).
Greengard, P., *Science* **199**, 146 (1978).
Ivey, F. J., Shaver, K., *J. Agric. Food Chem.* **25**, 128 (1977).
Kalliney, S. Y., "Topics in Phosphorus Chemistry", Vol. 7, Interscience, New York, 1972, p 255.
Lifson, N., Lorber, V., Sakami, W., Wood, H. B., *J. Biol. Chem.* **176**, 1263 (1948).
Martens, W. S., Rieman, W., *J. Polymer Sci.* **54**, 603 (1961).
McCullough, J. F., Van Wazer, J. R., Griffith, E. J., *J. Am. Chem. Soc.* **78**, 4528 (1956).
Roberts, S., Ashley, C. D., *J. Biol. Chem.* **253**, 288 (1978).
Reiman, W., Beukenkamp, J., "Treatise on Analytical Chemistry. Part II. Analytical Chemistry of the Elements", Vol. 5, Interscience, New York, 1961, p 317.
Speziali, G. A. G., Van Wijk, R., *Biochim. Biophys. Acta* **235**, 466 (1971).
Van Wazer, J. R., "Phosphorus and Its Compounds. Vol. I: Chemistry", Interscience, New York, 1958, p 788.

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Dicamba in Lysimeter Runoff and Percolation Water

The postemergence herbicide dicamba was applied at 5.6 kg/ha on May 1, 1974, to Lysimeter Y101C and to an adjacent soil plot (4.1 m^2) at the North Appalachian Experimental Watershed at Coshocton, Ohio. An August storm produced runoff that contained 0.23 ppb of dicamba. We detected 1.0 ppb of dicamba in the percolate water at the 2.4-m depth 11 months after application. The data are compared with earlier measurements of 2,4,5-trichlorophenoxyacetic acid and picloram found in runoff and percolation water from this lysimeter. The results indicate that the loss of dicamba in runoff and percolate water will not be a source of groundwater pollution.

Dicamba (2-methoxy-3,6-dichlorobenzoic acid) is a postemergence herbicide used in the selective control of broadleaf and grassy weeds in cereal crops, pasture, and turf area. Studies on the movement of dicamba in runoff water (Trichell et al., 1968) and in leachate from soil columns (Harris, 1964) showed that the herbicide moves laterally, upwardly and downwardly in the soil. Dicamba degradation studies showed that the substance undergoes microbial breakdown in the soil with over 50% loss in 4 weeks (Smith, 1974). In the present work, dicamba residues were monitored for 1 year in runoff and percolate water from a field lysimeter to determine if the use of this herbicide would cause groundwater pollution.

EXPERIMENTAL SECTION

Lysimeter and Treatment. The soil on Lysimeter Y101C (4.26 × 1.89 × 2.44 m) at the North Appalachian Experimental Watershed at Coshocton, Ohio, is Muskingum silt loam with 1.72% organic matter and pH of 5.0. The predominant vegetation growing over the lysimeter was bluegrass and broadleaf weeds. On May 1, 1974, we applied the dicamba formulation Banvel D at a rate of 5.6 kg/ha of the active ingredient to the lysimeter and a plot of soil (4.1 m^2) adjacent to the lysimeter that was used for removing surface soil samples for residue analysis. The 5.6 kg/ha rate is three–ten times the commonly used rate for weed control. Monthly soil samples consisting of 20 cores (2.5 cm deep × 29 mm diameter) were collected, placed in polyethelene bags, and then frozen.

Runoff and Percolation Water. Samples from storm runoff were collected and stored automatically in an underground storage chamber. Percolation water samples were collected manually 2.4 m below the lysimeter surface. All chemical analyses were conducted at Beltsville, MD.

Dicamba Analyses. After acidification with 10 mL of 1 N H_2SO_4, dicamba was extracted from 250-mL aliquots of runoff and percolation water samples with 100 mL of ethyl ether. The ether extract was dried over anhydrous sodium sulfate and concentrated to a final volume of 2 mL. The methyl ester of dicamba was prepared and quantitated on a gas chromatograph equipped with an electron-capture detector as described by Woolson and Harris (1967). Protective gloves and a face shield are recommended for the handling of diazomethane and ethyl ether because of the highly explosive nature of these chemicals.

Soil samples from the plot adjacent to the lysimeter were first thawed, air-dried, and put through a 2-mm seive. Subsamples were removed for moisture determinations. To a 20-g soil sample we added 100 mL of methanol and 25 mL of 1 N H_2SO_4. The suspension was shaken for 1 h and centrifuged. The liquid phase was poured into 200 mL of distilled water. Dicamba was extracted from the aqueous methanol solution with ethyl ether and analyzed using the same procedure as described above for the water samples. Recoveries of dicamba from soils fortified at 2 ppm were between 85 and 90%. The minimum level of

Table I. Concentrations of Dicamba, Picloram, and 2,4,5-T (ppb) Measured in Lysimeter Percolation and Runoff Water[a]

	dicamba (5.6 kg/ha)[b]			picloram (2.24 kg/ha)[b]			2,4,5-T (11.2 kg/ha)[b]		
month	percolate, ppb	runoff, ppb	rainfall, cm	percolate, ppb	runoff, ppb	rainfall, cm	percolate, ppb	rainoff, ppb	rainfall, cm
Mar									
Apr				0	14.5	4.8	0	227.0	7.5
May	0	n.d[c]	11.3	0	12.2	9.3	0	90.1	12.1
Jun	0	n.d	7.1	0	11.0	8.2	0	n.d	1.7
Jul	0	n.d	6.9	0	6.1	9.4	0	4.1	17.2
Aug	0	0.23	18.3	0	2.9	1.3	0	13.0	3.0
Sept	0	0.54	8.7	0	1.1	9.9	0	6.0	8.7
Oct	0	n.d	3.2	0	0.7	8.8	0	n.d	4.0
Nov	0	n.d	8.6	0	0	7.3	0	3.0	21.6
Dec	0	n.d	10.9	0	0	6.3	0.5	n.d	7.4
Jan	0	n.d	9.8	0	n.d	3.2	<0.1	3.0	8.4
Feb	0	n.d	8.9	0	n.d	8.9	<0.1	n.d	1.2
Mar	0.7	n.d	8.4	1.0	n.d	6.4	<0.1	1.3	12.0
Apr	0.2	n.d	9.2	1.2	n.d	1.9	n.d	3.0	4.7
May	0	n.d	20.1	0.7	n.d	10.9	n.d	n.d	15.4
			131.4			96.6			124.9

[a] Values represent the means of duplicate determinations. [b] Dates of application: dicamba, May 1, 1974; picloram, March 25, 1970 (Glass and Edwards, 1974); 2,4,5-T, March 30, 1967 (Edwards and Glass, 1971). [c] n.d, not determined.

Table II. Concentrations of dicamba (ppb)[a] measured in soil plot adjacent to Lysimeter, Y101C

month	dicamba, ppb	month	dicamba, ppb
Jun	150	November	9
Jul	70	December	14
Aug	52	January	n.d
Sept	40	February	12
Oct	10	March	<1

[a] Values represent the means of duplicate determinations.

detection for dicamba was 10 and 0.1 ppb in the soil and water samples, respectively.

RESULTS AND DICUSSION

The concentrations of dicamba found in runoff and percolation water samples from Lysimeter Y101C are shown in Table I. These results are compared with the concentrations of picloram (Glass and Edwards, 1974) and 2,4,5-T (Edwards and Glass, 1971) measured earlier in water samples from Lysimeter Y101C. Picloram at 2.2 kg/ha and 2,4,5-T at 11.2 kg/ha were applied to the lysimeter on March 25, 1970, and March 30, 1967, respectively. Residues of dicamba at 0.7 ppb were first detected in the percolation water 10 months after application. Dicamba residues were detected in only two monthly sampling periods. In comparison, picloram residues emerged from the 2.4-m thick block of soil at 1.0 ppb 11 months after application and 2,4,5-T appeared in the water at 0.5 ppb 9 months after application. In the two runoff samples collected after storms in August and September, 0.23 and 0.54 ppm of dicamba were measured, respectively.

The residues of dicamba measured in the soil samples taken adjacent to the lysimeter are shown in Table II. Nearly 50% of the dicamba measured in the June soil sample disappeared by the July sampling period. The investigation by Altom and Stritzke (1973) showed that the half-life of dicamba varied between 17 and 32 days in various soils. They attributed the disappearance of dicamba to microbial degradation. The rate of disappearance in our test falls within their range of the calculated half-life of dicamba; however, our data are insufficient to support any pathway of loss. However, we found the concentrations decreased most rapidly during the warm summer months and tended to remain constant between October and March when microbial activity was least and leaching greatest. The data presented in this investigation indicate that the loss of dicamba in runoff and percolation water will not be a source of groundwater pollution on silt loam soil.

LITERATURE CITED

Altom, J. C., Stritzke, J. F., *Weed Sci.* **21**, 556 (1973).
Edwards, W. M., Glass, B. L., *Bull. Environ. Contam. Toxicol.* **6**, 81 (1971).
Glass, B. L., Edwards, W. M., *Bull. Environ. Contam. Toxicol.* **11**, 109 (1974).
Harris, C. I., *Weed Sci.* **12**, 112 (1964).
Smith, A. W., *J. Agric. Food Chem.* **22**, 601 (1974).
Trichell, D. W., Morton, H. L., Merkle, M. G., *Weed Sci.* 16, 447 (1968).
Woolson, E. A., Harris, C. I., *Weed Sci.* **15**, 168 (1967).

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