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Organic Matter Effects on Phase Partition of 1,3-Dichloropropene in Soil

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1. INTRODUCTION

Soil fumigants are heavily used in the production of many food crops to control soil-borne pathogens, nematodes, weeds, and insects. Fumigants are intrinsically volatile, and the volatility is essential for achieving effective pest control. However, the high volatility has often resulted in offsite movement of fumigants and their pollution of air and groundwater. The California Air Resources Board conducted ambient air monitoring of pesticides near application sites in California and found potentially unsafe levels of methyl bromide (MeBr), methyl isothiocyanate (MITC) and 1,3-dichloropropene (1,3-D). Atmospheric emission of MeBr has been linked to the depletion of stratospheric ozone. An international agreement to phase out ozone-depleting chemicals will reduce MeBr supply by 70% in 2003 before a complete elimination in 2005 in the United States.

The main objectives of this study were to determine the air-water and soil-water partition coefficients of fumigant 1,3-D, and to evaluate the response of 1,3-D adsorption to changes in organic matter content caused either by different soil types or by the amendment of organic wastes. Partition coefficients were determined by simultaneously measuring the concentrations in the different phases at equilibrium.

2. MATERALS AND METHODS

Chemicals and Soils : The 1,3-D standard containing 48% *Z* isomer and 49% *E* isomer was purchased from Chem Service (West Chester, PA). Telone EC, an emulsifiable formulation of 1,3-D (40% *Z* isomer and 40% *E* isomer), was provided by Dow AgroSciences (Indianapolis, IN).

Four soils were used in this study: Arlington (Ar), Salinas (Sa), King City (Ki), and Florida muck (Fl). The Ar soil (Coarse-loamy, Mixed, Thermic, Haplic Durixeralf) was taken from the top 30 cm of a field at the University of California, Riverside, Agricultural Experiment Station. The Sa (Fine-loamy, Mixed Thermic Typic Argixerroll) and Ki (fine loamy, mixed, Thermic Fluventiehaploxeroll) soils were taken from agricultural fields near Salinas and King City, CA, respectively. The Fl soil (Euic, Hyperthermic Lithic Medisaprists, Muck) was provided by the Everglades Research and Education Center in Belleglade, Fl. A compost made of steer manure and biosolids was purchased from a local hardware store

Soil-Water Partition Experiment : Adsorption of 1,3-D from aqueous solution to soil was determined by batch equilibration (*11*). Aqueous solutions containing 1,3-D at 50, 100, 200, 350 and 600 mg L-1 were prepared by adding Telone EC and 200 mg L-1 of $HgCl_2$ in deionized water. Addition of $HgCl_2$ was to inhibit the biological degradation of 1,3-D. Twenty mL of each solution was added to 5.0 g of soil (dry weight) in a 50-mL centrifuge tube (triplicate samples). The centrifuge tubes were tightly capped and mechanically shaken for 16 h at room temperature. A preliminary experiment showed that the 16-h period was sufficient for achieving equilibrium. The centrifuge tubes were then centrifuged for 5 min at 10,000 rpm and 4C. To determine the concentration of 1,3-D in the solution phase (*Cw*, mg L-1), a 0.5 mL aliquot of the supernatant was withdrawn with a gas-tight syringe and extracted with ethyl acetate using the procedures given above. An aliquot of the ethyl acetate extract was quantified for 1,3-D concentrations on GC. After the supernatant was decanted, the centrifuge tube (with soil) was weighed to determine the amount of solution remaining in the soil pellet. To determine the concentration of 1,3-D in the solid phase (*Cs*, mg kg-1), 10 mL ethyl acetate and 10-g anhydrous sodium sulfate were added to the centrifuge tubes. The sample tubes were tightly capped and mechanically shaken for 30 min. Following centrifugation, an aliquot of the ethyl acetate phase was transferred into a GC vial and analyzed by GC.

3. RESULTS AND DISCUSSION

The fumigant 1,3-D is a major replacement for MeBr that will be phased out by the year 2005. In order to develop practices that are more environmentally compatible, the distribution of 1,3-D among the air, water, and soil phases needs to be better understood. The measured *KH* and *Kf* values of 1,3-D isomers in a number of California soils suggests that 1,3-D is extremely mobile in soil and has a high potential for offsite transport, e.g., emission into the air and movement to groundwater. This study showed that adsorption of 1,3-D was influenced by soil organic matter and was enhanced after addition of organic wastes. Therefore, organic amendment may be an option for reducing 1,3-D emissions during soil fumigation.

4. ABSTRACT

The fumigant 1,3-dichloropropene (1,3-D) is a major replacement to methyl bromide

(MeBr). This study was conducted to better understand phase partitioning of 1,3-D and the role of organic matter in its adsorption to soil. Partitioning of 1,3-D between air and water (*KH*) and soil and water (*Kf*) was determined by quantifying the concentration in both phases upon equilibrium. At 20C, the *KH* of (*Z*)- and (*E*)-1,3-D was 0.052 and 0.033, respectively. In three California soils, the *Kf* of 1,3-D isomers ranged from 0.39 to 0.60, and the *Koc* ranged from 35 to 60. The relatively high *KH* and low *Kf* imply that 1,3-D is highly mobile in most soils after subsurface application. Adsorption of 1,3-D in native soils and soils amended with manure compost increased with increasing soil organic matter content. This suggests that organic wastes may be applied to soil to increase 1,3-D adsorption, thus reducing its potential for offsite movement.

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