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Influence of organic amendment on the adsorption and leaching of ethametsulfuron-methyl in acidic soils in China

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Abstract

The sorption and leaching of ethametsulfuron-methyl by an acidic soil, after organic amendment with humic acid (HA) and a commercial peat, were studied in batch and soil column experiments. Adsorption capacity (K_f) values, obtained by fitting the experimental data to the Freundlich equation, ranged from 4.39 for the original soil containing 1.02% OC to 10.56 for the organic amended soils containing 2.61% OC. The increase in herbicide adsorption by organic amendment addition to soil was attributed to the high adsorptive capacity of the insoluble organic matter added to the soil. Evidence provided by FT-IR analysis suggested multifunctional hydrogen bonds were involved in the adsorption of ethametsulfuron-methyl on organic matter. The distribution of ethametsulfuron-methyl along the soil profile, obtained from soil column experiments, indicated that the amount of ethametsulfuron-methyl retained ranged from 68.4% for the column filled with the original soil to 92.4% for that filled with the organic amended soil. Amounts of ethametsulfuron-methyl recovered in the leachates, which ranged from 7.7% (organic amended soil) to 23.7% (unamended soil) of that applied, depended upon the loading rate and the source of organic amendment. Organic amendments significantly reduced the leaching of ethametsulfuron-methyl, and humic acid showed the higher potential than peat. This research suggests that organic amendment may be an effective management practice for controlling pesticide leaching.

Keywords: Ethametsulfuron-methyl; Adsorption; Leaching; Organic amendment; Soil

1. Introduction

The leaching of pesticides into the groundwater from agricultural practices is receiving increasing attention. In this process, the physicochemical properties of the compounds used, as well as soil properties, play a decisive role (Sawhney and Brown, 1989; Close et al., 1998). The displacement of pesticides from soil to water strongly depends on the extent to which they are retained in soils, which in turn depends on the adsorption and desorption properties of the soil (Hutson and Roberts, 1990).

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As a regional factor, the vulnerability of the groundwater has to be taken into account where geological formation has an influence on the possible contamination of groundwater by pesticides as well as texture, clay content, and content of organic carbon in the soil. It is generally accepted that adsorption of pesticides by soils is more closely related to the soil organic matter content than any other single property (Hutson and Roberts, 1990).

Organic matter amendment of soils is a very common practice in areas of intensive horticultural production (based on plastic greenhouses) in the Red Soil region (Southeastern China), where the native soils are of poor quality. Organic amendment can cause changes in soil structure and transport characteristics, including increased porosity, decreased bulk density, increased water retention, and changes in pore size distribution (Tester, 1990). Soil amendment also affects pesticide binding (Senesi et al., 1997), which can affect pesticide transport and ultimate distribution in the soil profile. The presence of dissolved organic matter has proved to enhance the aqueous solubility of organic pollutants to such an extent that transport through soil can be significantly influenced (Williams et al., 2000; Graber et al., 2001; Haberhauer et al., 2002). On the other hand the addition of humic substances could also increase retention of organic pollutants (Benoit et al., 1996; Celis et al., 1998; Conte et al., 2001).

Ethametsulfuron-methyl {methyl 2-[[[[(4-ethoxy-6-methylamino-1,3,5-triazine-2-yl) amino] carbonyl] amino] sulfonyl] benzoate} is a widely applied herbicide for postemergence weed control in oilseed rape (*Brassica napus* L.) (Lichtner et al., 1995; Van Eerd and Hall, 2000; Veldhuis et al., 2000). Because of moderately high water solubility (378 mg kg^{-1}, pH 7), ethametsulfuron-methyl has a high potential for leaching into groundwater, and it moves preferentially in percolating water rather than in eroded soil (Beyer et al., 1988). Degradation of ethametsulfuron-methyl in soils was pH-dependent (pK_a 4.6); it was more persistent in neutral or weakly basic than in acidic soil. The DT_{50} of ethametsulfuron-methyl at 25 °C in a loam soil (pH 5.0, 1.8% organic matter) under laboratory aerobic conditions was approximately 18 days (Si et al., in press). The degradation pathways included the cleavage of the sulfonylurea bridge, *N*- and *O*-dealkylation, and triazine ring opening (Si et al., 2005).

The objective of this work is to evaluate the sorption and mobility of the herbicide ethametsulfuron-methyl in organic carbon amended soils. This evaluation was carried out by studying the sorption process in batch experiments, to obtain the corresponding sorption isotherms and sorption capacities, as well as the mobility in column experiments, to determine the leaching potential of ethametsulfuron-methyl. We compared the sorption and mobility of the herbicide by using soil samples of varied organic matter content.

2. Materials and methods

2.1. Chemicals

Technical ethametsulfuron-methyl (Fig. 1, 97.5%) was obtained from Du Pont Inc., Wilmington, USA. Before use, ethametsulfuron-methyl was further purified to analytical grade by column chromatography. The purity was determined by high performance liquid chromatography (HPLC) and found to be greater than 99%. Analytical grade reagents were locally procured and purified before use.

2.2. Samples used as adsorbents

The soil chosen for this study was an acidic soil (Red Soil) from the Yingtan region (Southeastern China). Soil samples were collected from the surface (top 20 cm), air-dried, and passed through 2-mm sieve. The composition of the soil was: sand 22.5%, silt 21.3%, clay 56.2%, and organic matter 1.8%, cation exchange capacity (CEC) 14.30 cmol kg^{-1}, pH (1:1, H_2O) 4.95.

Humic acid was extracted from another soil containing a higher organic carbon content according

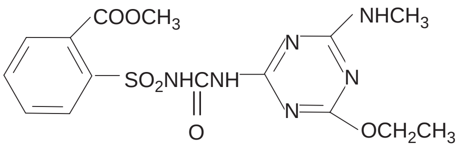

Fig. 1. Chemical structure of ethametsulfuron-methyl.