Influence of soil aggregate size on atrazine sorption

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The effects of numerous soil properties including texture (7); pH (1); mineralogy (5); and organic matter content (4) on atrazine [6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] sorption have received considerable attention. However, information on the effects of soil aggregate size on the sorption and movement of atrazine is relatively limited. More research is needed to evaluate aggregate size effects on atrazine sorption since these interactions are considered to be an important factor in solute sorption and movement (2). Our objective was to examine the sorption of atrazine to a suite of whole and crushed aggregates obtained from an Iowa glacial till soil.

Materials and methods

Isolation of Soil Aggregates. Six sizes (0 to 0.5, 0.5 to 1, 1 to 2, 2 to 3, 3 to 4, and 4 to 5 mm) of whole soil aggregates were obtained by sieving the Ap horizons (0 to 15 cm) of Wisconsinan-age glacial till (Clarion loam; Fine-loamy, mixed, mesic Typic Hapludolls) soil. Soil location, cropping history, aggregate extraction and physio-chemical properties have been described by Collado and Karlen (3). The sorption of atrazine to crushed aggregates (< 0.4 mm) was also determined to remove the effects of intra-aggregate porosity on sorptive processes.

Sorption. Batch sorption of atrazine was performed by equilibrating 4g air-dried whole (all isolated sizes) and crushed aggregates with 20 mL of 2 mg L^{-1} atrazine dissolved in 0.01*M* $CaCl_2$. Replicate centrifuge tubes along with controls (atrazine without soil) were agitated for 72 h. Atrazine in the equilibrium solution was determined by HPLC. The difference between initial atrazine concentration (mg L^{-1}) and in the equilibrium solution was attributed to sorption by soil aggregates. The sorption K_d (L kg^{-1}) was calculated as:

$$K_d = \text{mg atrazine kg}^{-1} \text{ soil/mg atrazine L}^{-1} \text{ eq. soln.} \qquad [1]$$

Kinetics. Batch techniques were used to measure atrazine sorption kinetics on 0 to 0.5, 1 to 2, and 3 to 4 mm whole soil aggregates from both soil types using similar methods. Kinetic data was analyzed using nonlinear least squares procedures (6) using the regression equation:

$$S_T = S_i(1-e_1^{-kt}) + k_2t \qquad [2]$$

where S_T is total atrazine sorbed to soil (mg Kg^{-1}), S_i is the initial atrazine sorbed (mg Kg^{-1}), k_1 is a first-order rate constant (h^{-1}), and k_2 (mg h^{-1}) is a zero-order rate constant describing the increase in atrazine sorption above S_i.

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Results and discussion

Atrazine K_d values for both whole and crushed ranged between 3.02 and 3.63 (Figure 1). Comparing the whole aggregate atrazine K_d values within soil type, the smallest aggregate size (0-0.5 mm) had significantly different values (1-way ANOVA, $P < 0.05$). Although, these differences are statistically significant, we believe that the magnitude of the aggregate effects on atrazine K_d are minor. Crushing the aggregates to a common size (0.4 mm) did produce some significant atrazine K_d differences for the 1 to 2 and 3 to 4 mm aggregate sizes (1-way ANOVA, $P < 0.05$). These differences were also significant, however we believe that the magnitude of the atrazine K_d differences are small enough to be ignored.Aggregate size had little effect on atrazine sorption kinetics (Table 1). Values of S_i increased and k_1 decreased in the 3-4 mm diameter aggregates compared to the 0-0.5 mm aggregates. Values of k_2 were significantly different from zero for all regressions (Table 1). However, the k_2 values are quite small in magnitude. In the initial 24 h first-order sorption reactions were rapid, but in some aggregate size classes slower, zero-order reactions were evident later in the time-course (Figure 2).

References cited

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Table 1. Kinetic parameters describing atrazine sorption to soil aggregates during batch equilibrium experiments. Values in parentheses are standard errors of the parameter estimates.

Soil	Size	Parameters		
		S_i	k_1	k_2
	mm			
Clarion	0-0.5	2.22(0.06)	3.11(1.09)	0.0048(0.0016)
	1-2	2.40(0.05)	2.37(0.36)	0.0054(0.0012)
	3-4	2.49(0.04)	1.65(0.14)	0.0067(0.0010)

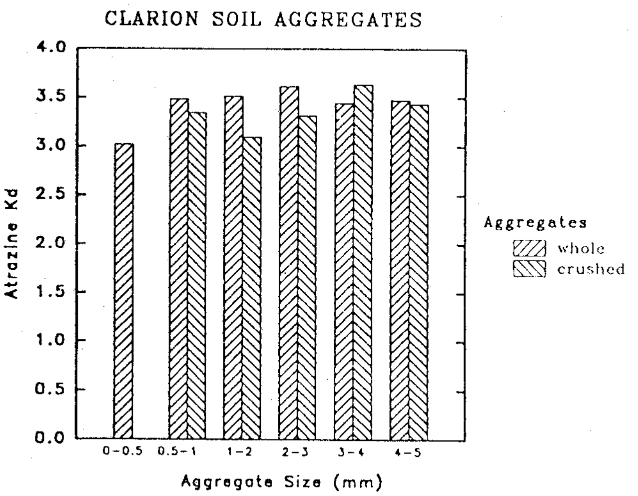

Figure 1. Atrazine K_d values for whole and crushed Clarion soil aggregates.

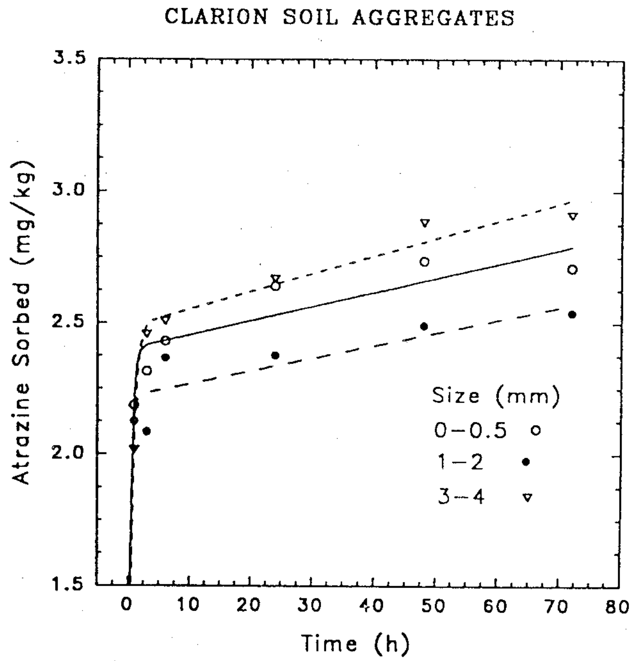

Figure 2. Atrazine sorption kinetics for 3 sizes of whole Clarion soil aggregates. Symbols represent means and the lines represent predicted quantities of sorbed atrazine. (S_t).