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Sorption-desorption behavior of 2,4-Dichlorophenoxyacetic Acid in Volcanic Ash Soil and Kaolinite

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Pesticide desorption process controls release rate of adsorbed pesticide and its subsequent movement towards groundwater resource. Understanding of hysteretic characteristic, which is typically observed in desorption of pesticide from soils is very important. Although the sorption of 2,4-dichlorophenoxyacetic acid (2,4-D) herbicide onto various soils has been widely reported, the study of 2,4-D desorption from the soils especially volcanic ash soils having variable pH-dependent charged characteristic is still very scarce. In this study, sorption-desorption behavior of 2,4-D from a volcanic ash soil sampled from Nishi-Tokyo, Japan was investigated under different pH conditions. In addition, kaolinite (pure clay mineral) obtained from Clay Science Society of Japan (CSSJ) was also used as a comparison of volcanic ash soil.

Consecutive desorption experiments were conducted after batch adsorption experiments with three concentrations of 2,4-D (2.5, 5, and 10 mg/L) in triplicate under three pH conditions (natural pH, 5.0, 4.0). The 2,4-D solutions were prepared in artificial rain water (ARW= 0.085 mM NaCl + 0.015 mM CaCl2) for volcanic ash soil and in deionized water for kaolinite. The sample solutions were prepared by adding 10 mL of 2,4-D solution into either 1 g of the soil for volcanic ash soil or 0.5 g of kaolinite. Under a specified pH condition, consecutive desorption experiment was repeated three times after one batch adsorption experiment to obtain a desorption isotherm with three desorption steps.

All sorption and desorption isotherms followed well with the Freundlich isotherm model. The adsorption of 2,4-D increased significantly for volcanic ash soil and slightly for kaolinite with decreasing pH. Moreover, volcanic ash soil has higher adsorption capacity of 2,4-D than kaolinite under the same pH because volcanic ash soil has higher organic matter content and different clay minerals including kaolinite. The desorption of 2,4-D from both volcanic ash soil and kaolinite exhibited hysteresis at each concentration under each pH condition. Hysteretic behavior in volcanic ash soil was markedly affected by pH and concentration of 2,4-D. The higher hysteretic index showing lesser desorption was obtained at lower pH and lower 2,4-D concentration. This observation related to hysteresis indicated that the adsorption of 2,4-D in volcanic ash soil under lower pH was mainly controlled by strong adsorption mechanisms. In addition, the association of 2,4-D to the soil at lower 2,4-D concentration was probably occurred at higher energy binding sites of the soil resulting in less desorption. For kaolinite, the effect of pH and 2,4-D concentration on hysteresis was very less as compared to volcanic ash soil likely due to the simple clay mineral characteristic of kaolinite.

Keywords: sorption-desorption, 2,4-Dichlorophenoxyacetic acid, volcanic ash soil, kaolinite, pH