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Effect of aggregate structure on VOC gas adsorption onto volcanic ash soil

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ABSTRACT

The understanding of the gaseous adsorption process and the parameters of volatile organic compounds such as organic solvents or fuels onto soils is very important in the analysis of the transport or fate of these chemicals in soils. Batch adsorption experiments with six different treatments were conducted to determine the adsorption of isohexane, a gaseous aliphatic, onto volcanic ash soil (Tachikawa loam). The measured gas adsorption coefficient for samples of Tachikawa loam used in the first three treatments, Control, AD (aggregate destroyed), and AD-OMR (aggregate destroyed and organic matter removed), implied that the aggregate structure of volcanic ash soil as well as organic matter strongly enhanced gas adsorption under the dry condition, whereas under the wet condition, the aggregate structure played an important role in gas adsorption regardless of the insolubility of isohexane. In the gas adsorption experiments for the last three treatments, soils were sieved in different sizes of mesh and were separated into three different aggregate or particle size fractions (2.0–1.0 mm, 1.0–0.5 mm, and less than 0.5 mm). Tachikawa loam with a larger size fraction showed higher gas adsorption coefficient, suggesting the higher contributions of macroaggregates to isohexane gas adsorption under dry and wet conditions.

1. Introduction

The understanding of the interaction between soils and volatile organic compounds (VOC) such as organic solvents or fuels has been a matter of growing concern due to increasing soil contamination [29]. Several field studies have shown that gas-phase contaminants can arrive at the water table ahead of a liquid contaminant plume [13,34]. The sorption of VOC gas strongly affects its transport and the amount that is retained in soil [27]. Therefore, it is important to understand the sorption process and the parameters that control transport in terms of the remediation of contaminants or risk assessment [26].

Several researchers have reported that VOC gas is strongly sorbed directly onto soil minerals under dry conditions [2,23,26]. At dry conditions, gas sorption is strongly affected by the soil-water content where an increase in soil-water content causes a rapid decrease in VOC gas adsorption capacity [23,24,26,32]. On the other hand, under the wet condition, VOC gas sorption is mainly dominated by dissolution to soil water, as expressed by Henry's law, and the gas adsorption capacity slightly increases as the soil-water content increases [24,26]. To date, the sorption of VOC gas, especially chlorinated organic compounds such as trichloroethylene (TCE) and toluene, has been studied with various soils and soil minerals at different soil-water contents [24,26,27]. However, few studies regarding gas sorption phenomena such as the aliphatic and aromatic phenomena of petroleum chemicals have been reported [29]. These petroleum chemicals are distinguished typically as a light nonaqueous phase liquid (LNAPL) and are less dense than water. As the water table fluctuates, LNAPL tends to be redistributed upward and downward over the vertical extent of the water table's rise and fall [13]. Hence, the high mobility of these petroleum chemicals near the soil surface has a significant impact on human health and the environment. In Japan, increasing concern about contaminated soils by petroleum chemicals [15] necessitates a better understanding of the physical and chemical interactions between these chemicals and soils.

Volcanic ash soils, which are widely distributed in Japan and account for one-sixth of the total land area [8], exhibit unique soil properties such as high water retention, large total porosity due to noncrystalline materials such as allophane, and good drainage, all of which are favorable for plant root growth [33,18]. Using the results of N_2 gas adsorption tests, Bartoli et al. [3] showed that the total micropore and meso-specific surface areas of volcanic ash soils

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