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# 学位論文内容の要旨

博士の専攻分野の名称：博士(農学) 氏名 Pham Viet Dung

## 学位論文題名

### **Influence of phosphate sorption on dispersion of a Ferralsol**

(リン酸収着がフェラルソルの分散に及ぼす影響)

#### **I. Introduction**

Soil dispersion/flocculation is a remarkable physical characteristic of soil structure and plays a decisive role in soil aggregation. Dispersion of colloidal soil is closely related to various environmental problems. Increase of soil dispersion can decrease the soil permeability and it sometimes induces erosion. Because the dispersed soil is transported in subsurface or surface runoff, adsorbed nutrients are also conveyed and they sometimes cause water contamination. Phosphate (P) is an essential element for the living organisms on the earth. P loss into water environment can cause the eutrophication. Because P is an important limited resource, it must be used effectively. In this study, the influence of P sorption on soil dispersion was investigated experimentally and evaluated by calculating repulsive potential energy based on zeta potential. Stability ratio was used to evaluate stability of colloid suspension. The influence was systematically investigated under different pHs and salt concentrations.

#### **II. Materials and Methods**

A Ferralsol was collected at a depth of approximately 10cm. It was air dried and sieved with a 2 mm sieve. Soil texture was light clay; sand (29.4%), silt (29.4%) and clay (41.3%). The minerals present in the clay fraction ( $<2\mu\text{m}$ ) were quartz (61%), kaolinite (34.4%), and goethite and hematite (4.6%). In the experiment we used monovalent (Na) and divalent (Ca) cations in 1 and 10  $\text{mmol}_c \text{L}^{-1}$  equilibrium salt solutions. The batch method of P sorption experiments was conducted at different pH 4, 5.5, 7 and 8.5 by adding  $\text{NaH}_2\text{PO}_4$  or  $\text{Ca}(\text{H}_2\text{PO}_4)_2$ . Salt concentration was supplemented by  $\text{NaNO}_3$  or  $\text{Ca}(\text{NO}_3)_2$  when the adding P concentration was less than 1 or 10  $\text{mmol}_c \text{L}^{-1}$ . Salt concentration increased when P solutions at concentrations larger than 1 or 10  $\text{mmol}_c \text{L}^{-1}$  were added. P sorption was calculated by subtracting the amount of P in the equilibrium solution from the amount of P added. Stability ratio (W), derived from dynamic light scattering method, was used to evaluate stability of colloid suspension. Stability ratio was calculated by  $k^f/k$ ;  $k^f$  is the rate of fast coagulation and  $k$  is the coagulation rate of the sample under consideration. When soil is flocculated well, stability ratio becomes unit. When soil is dispersed well, W becomes larger. Zeta potential, which is the electrical

potential near the solid-liquid interface obtained by using electrophoretic mobility, was calculated by using the Ohshima equation in the same conditions of P sorption experiments. The repulsive potential energy between the soil colloids when they approach at 1 nm was calculated using the zeta potential and the diffuse double layer theory.

### III. Results and Discussion

The soil was dispersed when the stability ratio was high. The stability ratio increased with increasing pH because the negative charge of the soil increased. Thus, the soil dispersed well with increase of pH. Depending on the pH, the stability ratio increased when P sorption increased because of increasing repulsive potential energy. The stability ratio increased when P sorption increased up to around 10 mmol P kg<sup>-1</sup> for Na system. At pH 5.5, the soil was dispersed well after phosphate sorption at about 0.15 mmol P kg<sup>-1</sup> (0.002 mmol P L<sup>-1</sup>) for the solution of initial Na solution concentration at 1 mmol<sub>c</sub> L<sup>-1</sup> and at about 14.5 mmol P kg<sup>-1</sup> (1.25 mmol P L<sup>-1</sup>) for the solution of initial Na concentration of 10 mmol<sub>c</sub> L<sup>-1</sup>. In Ca system, the stability ratio increased when P sorption increased up to 20 mmol P kg<sup>-1</sup> (at 0.7 mmol P L<sup>-1</sup>) at pH 4 and 5.5. The stability increased to the first peak when P sorption increased up to 2.6 mmol P kg<sup>-1</sup> (at 0.0016 mmol P L<sup>-1</sup>) and to the second peak at 250 mmol P kg<sup>-1</sup> sorption at pH 7 and 8.5. The soil was well dispersive even at 0 mmol P kg<sup>-1</sup> sorption at pH 8.5 for the solution of initial Ca concentration at 1 mmol<sub>c</sub> L<sup>-1</sup>. The soil was also well dispersive at around 250 mmol P kg<sup>-1</sup> (corresponding with 0.24 mmol P L<sup>-1</sup> for the electrolyte concentration of 0.4 mmol Ca L<sup>-1</sup>) at pH 8.5. When P was sorbed, the soil charge became more negative and the soil dispersed well due to the increase of the electric repulsive potential. The stability ratio increased again at around 250 mmol P kg<sup>-1</sup> at pH 7 and 8.5 because of the decrease of electrolyte concentration after Ca-P precipitation. It was confirmed from the result that the stability of the soil was correlated with the repulsive potential energy. In Na system, the soil flocculated well ( $\log W \leq 1$ ) when the repulsive potential energy was  $< 0.14 \mu\text{J m}^{-2}$ . Soil dispersed well ( $\log W \geq 1.15$ ) at repulsive potential energy  $> 0.34 \mu\text{J m}^{-2}$ . In Ca system, the soil flocculated well ( $\log W \leq 1$ ) at the energy  $< 0.27 \mu\text{J m}^{-2}$ . At the energy  $> 0.32 \mu\text{J m}^{-2}$  the soil was dispersed well ( $\log W \geq 1.15$ ).

### IV. Conclusion

We successfully evaluated the influence of phosphate sorption on the Ferralsol dispersion by calculating repulsive potential energy based on zeta potential. Because soil dispersion sometimes induces environmental problem, it is better to avoid the dispersive condition when applying phosphate fertilizers even if the soil is initially flocculative.