Increasing of Water-stability of Soils Aggregates by Water-based humic substances-silsesquioxane soft materials

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Abstract In this study, we showed how to effectively use water-based humic substances-silsesquioxane soft materials on the example of the poor soil. Samples in columns is treated by humics-silsesquioxane with different content of the organosilane. As a result of treatment coefficient of water-stability of soil aggregates increased significantly from 0.24 for water to 0.76 for humics-silsesquioxane with a high content of the organosilane.

Introduction

Soil aggregates are the basis of the soil structure. Soil quality depends on their nature or quantity. One of the key properties of the soil aggregates is their water-stability. The larger it is, the more the soil is able to maintain the water balance, so it is less susceptible to fracture. One of the methods to improve water-stability is to introduce humic substances.

However, humic substances are subject to migration and water washout. To prevent this, we have previously developed water-based humic substances-silsesquioxane soft materials, which are produced by treatment of humic substances with aminoorganosilanes (Volikov et al., 2016a, b). These compounds after their entering to soil form three-dimensional grid (fig. 1) and significantly increase the hydrophobicity and water-stability of soil aggregates (Volikov et al., 2016c). This work is a continuation of this theme, a more approximate to the fieldwork.

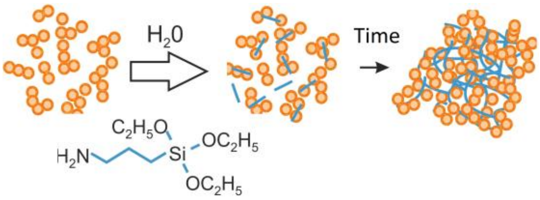

Fig. 1 Schematic interactions between HS and 3-aminopropyltriethoxysilane leading to the formation of aggregates

Materials and methods

For the experiment we used potassium humate potassium humate from coal (CHS) isolated from leonardite (Sakhalin Humate), technical-grade 3-aminopropyltriethoxysilane (APTES) purchased from Penta Ltd. (Moscow)

Into the series of columns placed 100 grams of poor soil, then slowly saturated by omitting the column into the glass with sample. As samples were used 10 g/l water solution of CHS, CHS+APTES-50 (CHS:APTES = 2:1 by weight), CHS+APTES-100 (CHS:APTES = 1:1 by weight) and distilled water as a blank. All sample solution were adjusted to pH 8 by 1M HCl. The column is then allowed to stand for a day, allowing the excess of fluid to drain. Then the soil was removed from the column and dried.

To estimate water-stability of soil macroaggregates, the method of Andrianov was used (Milanovskiy et al., 2013). The method is based on measuring the slaking rate of air-dried macroaggregates upon immersion into water. The soil was dry-sieved to isolate soil aggregates with sizes from 2 to 5 mm. Fifty of the isolated aggregates were evenly distributed over the filter paper on the bottom of a Petri dish. Then, the aggregates were first capillary water-saturated during 3 minutes by moisturizing the filter paper, then water was carefully added to the half-height of the Petri dish, kept for 10 minutes, and the amount of slaked aggregates was counted. The ratio of water-stable soil aggregates was calculated by the following formula:

$$K = \frac{\sum_{t=1}^{9}(c-a)*(\frac{t-1}{10}+0.05)+b}{c} \tag{1}$$

where t is the number of minutes, a is the number of slaked aggregates per minute, b is the number of water-stable macroaggregates, and c is the total number of aggregates.

Results and Discussion

Using soil columns bring us closer to the field experiment, but allow to perform experiments more quickly and reliably. In this case, we simulated soil treatment by solutions of humic substances-silsesquioxane and, as a control, humic substances and water only. As a result of treatment of the soil columns, we selected 2-5 mm soil aggregates and carried out research on their water-stability by Andrianov method, kinetic curves of aggregates slacking shown in Fig. 2.

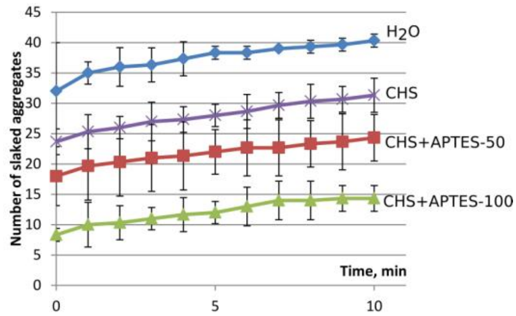

Fig. 2 Kinetic curves of aggregate slaking (sizes from 2 to 5 mm) treated with water, the coal humate (CHS), silanized HS (CHS-APTES-50 and CHS-APTES-100).

Table 1 contains counted according to the formula 1 coefficients of water-stability of soil aggregates treated with the corresponding samples. As expected, the introduction of humic substances increases water-stability. But the introducing of the humic substances-silsesquioxane soft materials further increase it, and it depends on the content of the organosilane. These results are explained by the fact that the silanol function covalently bind with free mineral surfaces in the soil, to reconcile with humic substances solid structure, thereby increasing the hydrophobicity and water-stability. Thus, these studies show promising use of water-based humic substances-silsesquioxane soft materials for processing of soil.

Table 1 Water-stability coefficients of treated aggregate.

Sample	K
H2O	0,24 ± 0,03
CHS	0,44 ± 0,04
CHS+APTES-50	0,56 ± 0,09
CHS+APTES-100	0,76 ± 0,05

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