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THE EFFECT OF AL HYDROXIDES ON THE STRUCTURAL STABILITY OF SOME MEDITERRANEAN SOILS

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Introduction

Aggregate breakdown and clay dispersion result in surface crust formation and soil erosion. Under the Mediterranean climatic conditions, the soil organic matter is usually low and its effect in stabilizing soil structure is restricted. So, the contribution of other soil components to structural stability is important.

In these soils, Fe and Al oxides have been found efficient in binding clay particles (Kostopoulou and Panayiotopoulos, 1993). The sesquioxides act i) as flocculants in lowering zeta potential of clays, ii) as links between clay and organic polymers and iii) as a cement after precipitation as gel on clay surfaces (Le Bissonnais, 1996). Aluminum oxides seem to be a more efficient agent of aggregation than iron because of the planar shape of the molecules that bloke effectively the cation exchange sites on clays (Oades, 1984; Gu and Doner, 1993).

The aim of this work is to evaluate the effect of Al hydroxides on clay dispersion of three soil types with different clay content and mineralogy, CEC and water aggregate stability (A.S.)

Materials and Methods

Eight surface soils from Northern Greece were used in this work. The soils were air dried and sieved to < 2 mm. Except of soils classified as Alfisols according to Soil Taxonomy, soils classified as Entisols and Vertisols were used in order to compare the experimental results.

Quantities of fresh prepared amorphous aluminum hydroxides (Prodromou and Kalovoulos, 1994) corresponding to 0.0, 0.05, 0.25, 0.50, 0.75, 1.00, 1.50 and 2.00g Al^{3+}/100g of soil were added to soil samples of 0.50g into 50 ml centrifuge tubes a) without any treatment of the soils and b) after previous saturation with 1M NaCl. In this case, the soils were treated three times with 25 ml 1M NaCl, shaken for 10 min. and centrifuged at 4000 rpm for 5 min.

After the saturation with Na^+, they were washed two times with 90% CH_3COCH_3 and then the quantities of aluminum were added. The final volume of the soil-Al suspensions was 20ml. The suspensions were shaken end-over-end for two different time periods: a) 15min. and b)18hrs and afterwards were allowed to stand vertically for 2hrs. A 4ml aliquot was then pipetted out of each tube at a depth of 2cm into a spectrophotometer cuvette.

The absorbency (A) was measured at a wavelength of 640nm (Thellier and Sposito, 1989). Deionized water was used as the 0,000A reference. The relative clay dispersion was then calculated as A/a, where A and a refer to the absorbance of soil suspensions with and without Al hydroxides added, respectively (Gu and Doner, 1993). The remaining soil suspensions were centrifuged and Al in the supernatant was determined by AAS.

Free Fe and Al oxides of the soils were extracted by the citrate bicarbonate dithionate method (CBD), (Weaver et al., 1968). All treatments and analyses were done in triplicate.

Results and Discussion

Some physical and chemical characteristics of the soils are shown in Table 1. The effect of Al hydroxides on the flocculation of the soil suspensions is shown in Figures 1-3. In all treatments, clay dispersion decreased considerably with small increase of Al hydroxide added.

Table 1. Chemical and physical characteristics of the investigated soils

Soil	Depth	Sand	Silt	Clay	pH	$CaCO_3$	OM	CEC	A.S.	Fe_2O_3	Al_2O_3	Classification
	(cm)	%	%	%	(1:2)	%	%	*	%	(mg/	100g)	
1	0-29	60.0	16.0	24.0	6.4	0.0	1.3	10.9	25.8	107.5	25.0	T. Haploxeralf
2	0-31	58.0	17.6	24.4	6.6	0.0	3.3	28.8	85.3	60.0	20.0	T. Haploxeralf
3	0-19	51.6	26.0	22.4	6.0	0.0	2.8	25.5	88.8	75.8	30.0	T.Haploxeralf
4	0-30	50.0	28.0	22.0	6.4	0.0	2.2	21.7	88.2	106.8	37.5	T. Haploxeralf
5	0-15	66.0	20.0	14.0	6.1	0.0	1.4	8.3	12.9	57.0	15.0	T. Xerofluvent
6	0-15	68.0	20.0	12.0	8.1	1.0	1.4	8.2	68.6	34.1	8.8	T. Xerofluvent
7	0-15	53.0	35.0	19.0	7.7	0.0	1.3	7.9	28.5	26.3	12.5	T. Xerofluvent
8	0-30	34.0	20.0	46.0	7.9	6.8	1.7	54.0	71.4	10.9	12.5	TGromoxerert

* CEC (cmol(+)kg^{-1})

The high affinity of clay surfaces for Al is indicated by the complete adsorption of Al hydroxides added to the soils as only traces of Al were detected in the supernatants. In most cases, Na-saturation retarded flocculation respectively to the untreated soil suspensions. The time of shaking had no effect on the relative clay dispersion.

In Entisols addition of Al caused the sharpest decrease and in all cases 0,25%Al was sufficient to flocculate the clay. This must be due to the low clay content and CEC of these soils (Tab. 1). However, excessive addition of Al (more than 1%) destabilized these soil suspensions that were not Na-saturated. Destabilization was greater for the 15min shaking period.

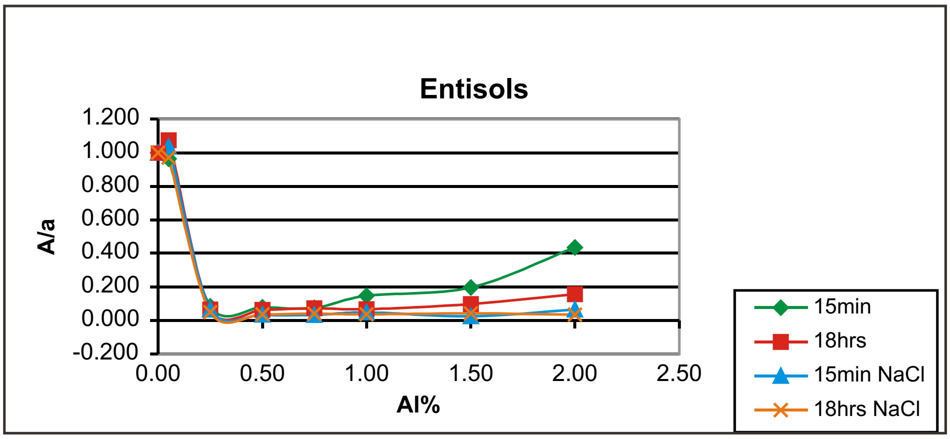

Figure 1. Influence of Al hydroxides on the dispersion of the Entisols

In Alfisols, complete clay flocculation occurred with addition of amounts of Al hydroxides greater than 0,50% while destabilization of the untreated suspensions began at addition of 2% Al hydroxides.

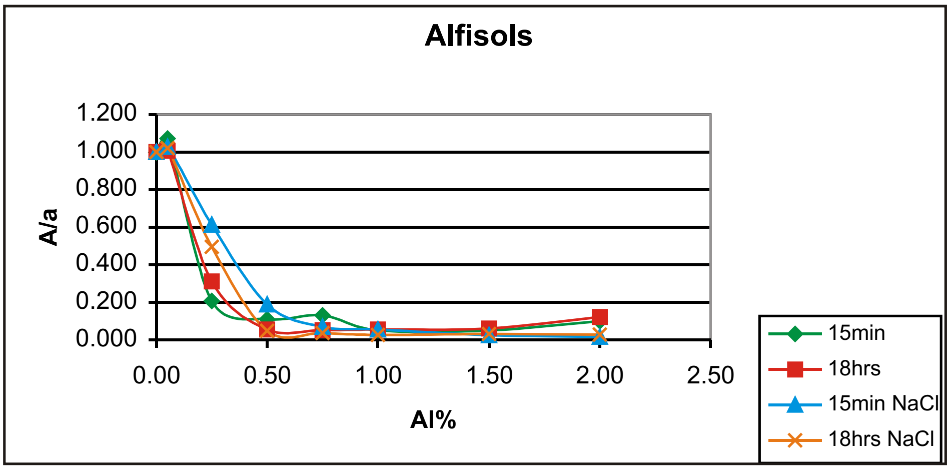

Figure 2. Influence of Al hydroxides on the dispersion of the Alfisols

In the Vertisol, complete clay flocculation occurred with addition of amounts of Al hydroxides greater than 0,75% while no destabilization was observed. This was expected because of the high montmorilonitic clay content and CEC of this soil. Also, in this soil flocculation was strongly retarded by Na-saturation, in low Al-h additions.

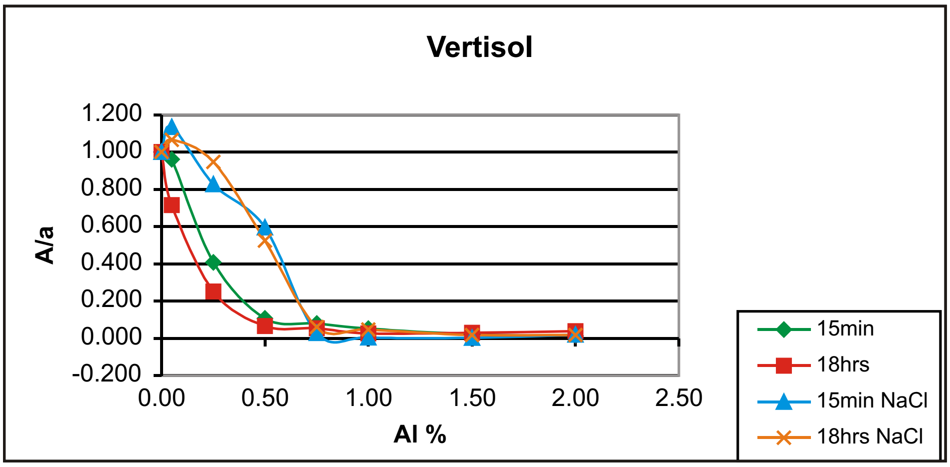

Figure. 3. Influence of Al hydroxides on the dispersion of the Vertisols

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