MODIFICATION OF SOIL PHYSICAL PROPERTIES BY ADDITION OF IRON AND CALCIUM COMPOUNDS

by

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SUMMARY

Soil structure is defined and various methods for characterizing structure briefly described followed by a description of factors involved in aggregation and flocculation-dispersion phenomena. In the literature, it is shown that physical, biological and chemical agents are involved in the aggregation. The importance of the inorganic components involved in stabilizing aggregates, iron oxides and hydroxides, gypsum and calcium carbonate have been studied. The solubility and feasibility of the use of gypsum are detailed in the literature.

The addition of 0.07%Fe in the form of polycation of molecular weight 10,000-50,000 flocculated soil suspensions. Higher concentrations of Fe(III) caused redispersion of the clay. Electrophoretic and electron microscopic studies confirmed the flocculation-dispersion phenomena. The soil suspensions with higher concentrations of Fe(III) gave points of zero charge (PZC) between pH values 5.0 and 6.0. The flocculation resulted in microaggregation and created pores 40-100 μm in diameter. This led to an increased water-holding capacity and hydraulic conductivity and lower bulk density and modulus of rupture. The soils treated with Fe(III) polycations were shown to be more friable than untreated soils.

The addition of 0.07%Fe or more decreased the total area of cracks and increased the number of transmissive pores of soils after simulated rainfall and drying. This resulted in increased percent emergence and lower mean day of emergence of wheat plants. Percent emergence (y) was negatively correlated with penetrometer resistance (x). The increased germination was followed by greater plant growth, including increased plant height and yield. The Fe polycation treatments had no significant effect on root length measured at harvest.

Three groups of anions were distinguished in order of effectiveness with respect to the dispersion and flocculation of soil samples treated with Fe(III) polycations: phosphate and fulvate > citrate, oxalate, silicate and tartrate > salicylate, catechol, aspartate, lactate and acetate. This was also the order of the amount of anion adsorbed by the soil. The addition of phosphate and fulvate to soil samples with a net charge of zero lowered the PZC producing particles with a net negative charge. This increased the amount of dispersible clay present from 0 to 9% by weight of soil. The sorption of phosphate and fulvate by soil samples with a net positive charge reduced the PZC and caused flocculation of dispersed clay. Electrophoretic and electron microscopic studies confirmed the dispersion-flocculation phenomena. Treatments which produced dispersed clay led to increased bulk densities, plastic limits and moduli of rupture but lower porosities, water holding capacities and hydraulic conductivities. The sorption of anions on soil samples with a net charge of zero reduced friability.

Three methods were compared for the determination of dispersible clay in the absence of chemical treatments. Treatment of the B horizon of a red-brown earth with a range of amounts (0-0.24%Fe) of Fe polycations allowed production of a range of dispersible clay contents from 0 to 70%. The samples of clay B horizon with decreasing contents of dispersible clay showed decreasing electrophoretic mobilities with zero mobility when the content of dispersible clay was zero. In such samples the clay particles were present in aggregates 50-250 μm diameter according to sedimentation techniques. The amounts of dispersible clay present appeared to control various physical and mechanical properties. It is suggested that the content of dispersible clay may be a useful quantitative characteristic of soils as it controls many other properties.

In a sodic soil to which calcium compounds such as gypsum, calcium carbonate or cement was added the content of dispersible clay was

related to both exchangeable sodium percentage (ESP) and electrical conductivity (EC). The electrolyte concentration in the sodic soil which could be maintained by addition of calcium carbonate was such that an ESP of ≅ 3 was required to maintain clay coagulation. Small amounts of gypsum (0.2% w/w) coagulated most of the clay by lowering the ESP and raising the electrolyte concentration. However, the clay gradually dispersed as the soil was subjected to wetting and drying cycles and the electrolyte concentration was decreased. The most efficient use of gypsum would appear to be in small annual additions. The addition of cement resulted in the stabilization of particles 250 -2000 μm diameter, i.e. cementation as opposed to coagulation. Both processes resulted in changes to various physical and mechanical properties of the soil. It is suggested that both coagulation and cementation in a soil may be possible by the addition of gypsum and cement or calcium carbonate with significant improvements of soil structure.