Effect of Clay Mineralogy and Aluminum and Iron Oxides on the Hydraulic Conductivity of Clay-Sand Mixtures[1]

N. Alperovitch, I. Shainberg, R. Keren and M. J. Singer

Institute of Soils and Water, Agricultural Research Organization The Volcani Center, P.O. Box 6, Bet-Dagan, Israel
Department of Land, Air, and Water Resources, University of California Davis, California 95616

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Abstract: Changes in hydraulic conductivity and clay dispersivity of clay-sand mixtures (four reference smectites and Fithian illite) as a function of concentration (0.01 M Cl^- and distilled water) and sodium adsorption ratio (SAR $\leqslant$ 30) of the percolating solution were measured. In addition, the effect of sand percentage, sand particle size, and addition of $AlCl_3$ and $FeCl_3$ on the hydraulic conductivity of the mixtures were measured.

Clay dispersion and migration out of the 3% clay columns was substantial. The clay dispersed only in the distilled water system; dispersion increased with an increase in the percentage of exchangeable Na and was about the same for the Wyoming montmorillonite and Fithian illite. Conversely, the clay swelled in the 0.01 M Cl^- solution. The swelling of the montmorillonites increased in the order: Upton, Wyoming = Belle Fourche, South Dakota > Polkville, Mississippi > Otay, California, and was higher than that of the Fithian illite. The swelling and dispersion of the clay accounted for the changes in hydraulic conductivity.

Mixtures treated with $FeCl_3$ and $AlCl_3$ were leached with NaCl-$CaCl_2$ solutions until the pH of the effluent exceeded 6.5. The composition of the exchangeable phase was then determined by the SAR of the leach solutions. At pH > 6.5, the polycations hydrolyzed and were present as the hydroxy-polymer species. The hydraulic conductivity of the mixtures decreased as exchangeable Na increased, but the decrease was less than in untreated mixtures, $AlCl_3$ was more effective in maintaining hydraulic conductivity than $FeCl_3$. In montmorillonite clay with an ESP of 20, less than 5% of a complete Al-interlayer was enough to prevent a reduction in hydraulic conductivity. Packets in the day systems tested explain the high efficiency of the Fe and Al polycations.

Key Words: Aluminum oxide • Exchangeable sodium percentage • Hydraulic conductivity • Illite • Iron oxide • Montmorillonite • Salinity • Sand

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