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Variation of the Hydraulic Conductivity of Clayey Soils in Exposure to Organic Permeants

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Abstract

Clayey soils are the most common material used in waterproofing and play an essential role in waste and contamination control. Permeability is a key parameter in such problems and its determination is needed in ensuring the satisfactory performance of the soil. Research has shown that a permeant fluid with a low dielectric constant can shrink the double layer around the clay particles which will, in turn, increase the permeability of the soil. In this paper, the permeability of two types of clay with different plasticity, exposed to the flow of water and methanol as polar and miscible solvents and gasoline and car oil as non-polar and immiscible solvents is investigated. In addition, the effect of soil properties such as plasticity and compaction water content on permeability of the samples is examined. To this end, soil samples are prepared and compacted at various water contents. Then, permeability tests are conducted according to the modified constant head method and the effects of parameters such as the fluid dielectric constant, water content of the samples and soil plasticity are examined. The results demonstrate that the lower dielectric constant of the organic fluid decreases the thickness of the double layer, providing more space for the flow of the permeant and as a result, the permeability of the clay increases. The reduction of the permeant dielectric constant from 80.4 to 2.28 led to a remarkable increase in soil permeability.

Keywords: Clay; Dielectric Constant; Organic Fluid; Permeability; Water Content.

1. Introduction

In many hydrological and geotechnical problems, soil permeability is considered a key parameter. In recent years, environmental concerns have led researchers to focus their attention on the hydraulic conductivity of clays, due to their important role in waste containment. Clay liners in waste disposal sites are examples where the hydraulic conductivity of clay, plays a critical role. Thanks to the accessibility of clay and lower expenses associated with its use, compacted clay layers are chosen as liners to inhibit the infiltration of contaminants present in solid and liquid wastes into the environment [1]. Following the standards imposed by the regulatory agency in Brazil, the compacted liner's water permeability should be lower than 1×10^{-9} m/s to minimize the potential infiltration [2].

The permeability of clayey soils exposed to the flow of water can be strongly affected by factors such as the grain size distribution (or specific surface), particle arrangements, degree of saturation, porosity, chemistry and concentration of electrolytes. In the case of Non-Aqueous Phase Liquid (NAPL) flow, the relationship between permeability and the physical and chemical properties of the fluid is even more complex [3].

Changes in clay hydraulic conductivity due to its exposure to chemicals have prompted research into the permeability of clay with permeants other than water. In soil with a high clay content, the interactions between the soil surface and the fluid are significant and influence the hydraulic conductivity [4]. In the case of NAPL flow, the highly variable

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