

RGB image analysis technique for quantification of dye concentration distribution in clay media

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This study investigates the applicability of image analysis techniques to link the concentration of sodium fluorescein with RGB color intensity, facilitating the quantification of concentration profiles in clay media. Mathematical relationships between dye concentrations and RGB intensities were established through batch adsorption tests using three different types of clay (kaolinite, montmorillonite, and bentonite). The channel showing the most consistent intensity variation across the dye concentration range was selected for acquiring concentration profiles in the diffusion chamber experiment, which were then validated by comparison with a 1-D analytical solution. The results of batch adsorption tests showed that the blue and green channels provided adequate concentration estimates for kaolinite and montmorillonite, respectively. For bentonite, a combined estimation from the blue and green channels was employed, tailored to specific dye concentration ranges. The blue channel intensity was found to decrease with the dye concentration up to 0 to 400 mg/L, while the green channel intensity gradually increased from 400 mg/L to 1800 mg/L. In the diffusion chamber experiment, the application of a single channel (blue for kaolinite and green for montmorillonite) resulted in favorable agreement with a 1-D analytical solution ($E_B=0.95$ for kaolinite and $E_G=0.95$ for montmorillonite). For bentonite, multi-channel applications ($E_{B+G}=0.98$) showed better agreement with the analytical solution than the single-channel application ($E_B=0.56$). Therefore, establishing the relationship between the optical characteristics of dye and the clay media is essential before employing image analysis techniques for quantifying dye concentration distributions.