



## Influence of Sulfate on the Transport of Bacteria in Quartz Sand

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The influence of sulfate on the transport of bacteria in packed quartz sand was examined at a constant 25 mM ionic strength with the sulfate concentration progressively increased from 0 to 20 mM at pH 6.0. Two representative cell types, *Escherichia coli* BL21 (Gram-negative) and *Bacillus subtilis* (Gram-positive), were used to determine the effect of sulfate on cell transport behavior. For both examined cell types, the breakthrough plateaus in the presence of sulfate in suspensions were higher and the corresponding retained profiles were lower than those without sulfate ions, indicating that the presence of sulfate in suspensions increased cell transport in packed quartz sand regardless of the examined cell types (Gram-positive or Gram-negative). Moreover, the enhancement of bacteria transport induced by the presence of sulfate was more pronounced with increasing sulfate concentration from 5 to 20 mM. In contrast with the results for EPS-present bacteria, the presence of sulfate in solutions did not change the transport behavior for EPS-removed cells. The zeta potentials of EPS-present cells with sulfate were found to be more negative relative to those without sulfate in suspensions, whereas, the zeta potentials for EPS-removed cells in the presence of sulfate were similar as those without sulfate. We proposed that sulfate could interact with EPS on cell surfaces and thus negatively increased the zeta potentials of bacteria, contributing to the increased transport in the presence of sulfate in suspensions.