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Interaction between bacteriophage and pyrophyllite clay in aqueous solution

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Viral contamination results in a degradation in drinking water quality and a threat to public health. Toprovide safe drinking water, water treatment alternatives using various adsorbents and filter media such as activated carbon, bituminous coal, quartz sand and clay have been considered. Pyrophyllite is a 2:1 clay mineral having dioctahedral layer structure with octahedrally coordinated Al ion sheets between two sheets of SiO_4 tetrahedra. It is a hydrous aluminosilicate clay with the chemical composition $AlSi_2O_5(OH)$. Pyrophyllite has recently been investigated as a potential low-cost and environmental friendly adsorbent for removing various contaminants. The aim of this study was to investigate the removal of the bacteriophage MS2 from aqueous solution using pyrophyllite. Batch experiments were conducted to examine the MS2 sorption to pyrophyllite. The influence of fluoride, a groundwater contaminant, on the removal of MS2 was also observed. Batch results demonstrated that pyrophyllite was effective in MS2 removal. The percent removal increased from 5.26% to 99.99% (= 4.0 log removal) as the pyrophyllite concentrations increased from 0.2 to 20 g/L. More than 99% of MS2 could be removed with a pyrophyllite concentration of $\geq$ 4 g/L. The sorption of MS2 to pyrophyllite was rapid. Within 15 min, approximately 99.98% (= 3.7 log removal) of MS2 was attained. More than 4.0 log removal was achieved after 180 min. The experimental data were analyzed with the pseudo first-order and pseudo second-order kinetic models. The correlation coefficient showed that pseudo second-order model was better than pseudo first-order model at describing the kinetic data. The amount of MS2 removed at equilibrium was determined to be 1.43×10^8 pfu/g from the pseudo second-order model. The experimental data were also analyzed with the Freundlich and Langmuir isotherm models. The correlation coefficients showed that the Langmuir model was more suitable than the Freundlich model for MS2 sorption data. The maximum amount of MS2 removed per unit mass of pyrophyllite was determined to be 5.01×10^8 pfu/g. Results also showed that at a pyrophyllite concentration of 20 g/L, the log removal in the presence of 5 mg/L fluoride was 3.05, which was lower than that for 0 mg/L fluoride. At the same concentration of pyrophyllite, the log removal in the presence of 10 mg/L fluoride was 2.54, which was lower than those for 0 and 5 mg/L fluoride. The removal of MS2 by pyrophyllite was thus shown to be influenced by fluoride ions. The results could be attributed to fluoride ions competing with MS2 for sorption sites on the pyrophyllite surfaces. Separate batch experiments indicated that the fluoride adsorption capacity of pyrophyllite was 0.124 mg/g at the given conditions (pyrophyllite concentration = 20 g/L; initial fluoride concentration = 5 mg/L; reaction time = 5 h), which indicated that fluoride could adsorb to pyrophyllite. This study can improve our knowledge on the application of pyrophyllite as adsorbents for virus removal in water treatment.

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