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Interaction of bacteriophage MS2 with Mg-Fe layered double hydroxides in synthetic groundwater

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Viral contamination becomes a great issue in groundwater, deteriorating drinking water quality and posing a great threat to human health. Many studies have been performed for removal of viruses from aqueous solution using various adsorbents, because solid materials are effective and inexpensive for the removal of viruses from sewage and drinking water. The main objective of this study was to compare the effectiveness between Mg-Fe layered double hydroxides (LDHs) as adsorbents for MS2, was selected as the model virus of human enteric virus, from aqueous solution. Effect of various environmental factors including reaction time, solution pH and competing anions (NO_3^-, SO_4^{2-}, CO_3^2, HPO_4^{2-}) were also studied. Equilibrium batch experiments were performed to examine sorption of MS2 on Mg-Fe LDHs with the initial bacteriophage concentration of $\sim 10^5$ pfu/mL. Four Mg-Fe LDHs, calcined at different temperatures (105, 300, 500, 700 ^{o}C), had quite a different sorption capacity of MS2. The removal percent (99.44 $\pm$ 0.48%) was the highest in the Mg-Fe LDH calcined at 300 ^{o}C (Mg-Fe-300 LDH) with the removal capacity of (2.34 $\pm$ 0.01) x 10^8 pfu/g. Further experiments were conducted with Mg-Fe-300 LDH at the different concentrations of LDH. In the LDH dose from 0.5 to 4.0 g/L, the removal percents in Mg-Fe LDH-300 ranged from 84.96 $\pm$ 1.57 to 99.60 $\pm$ 0.04% while the removal capacity were from (1.16 $\pm$ 0.01) x 10^8 to (7.88 $\pm$ 0.15) x 10^8 pfu/g. Results indicate that Mg-Fe-300 LDH, more than 99% of bacteriophage MS2 could be removed at the LDH dose of $>$ 2.0 g/L. Attachment of MS2 to Mg-Fe-300 LDH is a fast process. About 88% of MS2 was removed within 5 min and sorption reached at equilibrium after 1 hr. Within the pH range studied (2.7-12.3), the result showed that sorption of bacteriophage to Mg-Fe-300 LDH was not pH dependent. However, at extremely high pH (11.1-12.3), the removal percents of 99.99 % and 100 % were obtained, possibly due to inactivation rather than sorption. Regarding presence of anions in solution, NO_3^-, a monovalent anion, has no effect on the adsorption of MS2 to Mg-Fe LDH-300 at the concentrations ranging from 1 to 100 mg/L. Meanwhile, the divalent anions (SO_4^{2-}, CO_3^2, HPO_4^{2-}) had a profound interfering effect due to competition of anions with MS2 in the LDH sorption sites. The impact of the divalent anions are approximately in the order of $SO_4^{2-} < CO_3^{2-} < HPO_4^{2-}$. This study has helped improve our knowledge on the potential application of LDH as adsorbents for virus removal in water treatment.

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