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Virus (MS2, Î¦X174 and Aichi) transport through sand columns and their interaction force measurements by atomic force microscopy

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Abstract:

The main objective of this study was to investigate transport and retention of Î¦X174, MS2 and Aichi viruses through oxide-removed, goethite-coated and aluminum oxide-coated sand via column experiments. Previous studies reported that metal oxides have great potential for preventing the fate and transport of viruses in water treatment systems. Hence, we synthesized goethite-coated and aluminum oxide- coated sand and the coatings of metal oxides on sand surfaces were confirmed by scanning electron microscopy (SEM) and energy- dispersive X-ray analysis (EDXA). Retention of viruses on goethite-coated sand was 99.97% for Î¦X174, 99.99% for MS2 and 100% for Aichi virus, whereas aluminum oxide-coated sand was 99.98% for Î¦X174, 99.99% for MS2 and 100% for Aichi virus. In the present study, we used atomic force microscopy (AFM) to quantify the adhesion forces between viruses and oxide-removed, goethite-coated and aluminum oxide-coated sand. The average adhesion forces for aluminum oxide-coated sand is higher for all three virus than those of goethite-coated and oxide- removed sand due to its high zeta potential (15.2 mV) at pH 7.5 in artificial ground water (AGW) buffer solution. The AFM results were consistent with column experimental results. Beef extract solution (3%) was used to elude the retained viruses on sand column and the results suggested that the removal of MS2 was largely due to reversible while the removal of Î¦X174 and Aichi was inactivation/irreversible. To assess the nature of virus interactions with mineral surfaces, zeta potentials of both viruses and sand (clean and metal oxides coated) are measured and used for calculating standard Derjaguin Landau Verwey Overbeek (DLVO) and extended DLVO potential energy profiles. DLVO theory suggested that repulsive interactions between Î¦X174, MS2 and Aichi and oxide-removed sand where as attractive interactions for goethite-coated sand and aluminum oxide-coated sand. Additionally, hydrophobic interactions not played significant role in extended DLVO energy profiles due to low contact angles of viruses.

Impact Statement:

We obtained good progress in this project with several exiting results. Some of them are below.

1) This is the first study to use AFM to see the virus-sand interactions. We found good agreement between experimental results and AFM data.

2). Very little research has been done to study DLVO energy profiles of viruses and sands. We measured zeta potential values of viruses and sands and calculated the DLVO energy profiles.

3) We measured several new things like contact angle of viruses (for extended DLVO calculations), coating viruses on AFM tip etc and succeeded with good results.

4) Overall we found very good results in this project.

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