Report as of FY2010 for 2009ND186B: "Development of GAC-NZVI Adsorbent for Arsenic Removal"

Publications

- Dissertations:
  - Chang, Qigang, Ph.D., Environmental and Conservation Sciences Program, College of Graduate and Interdisciplinary Studies, North Dakota State University, August 2011. Iron-Impregnated Granular Activated Carbon for Arsenic Removal from Drinking Water. Major Professor: Dr. Wei Lin.
- Articles in Refereed Scientific Journals:
  - Chang, Q.G.; Lin, W.; Ying, W.C. (2010) Preparation of iron-impregnated granular activated carbon for arsenic removal from drinking water. J. Hazard. Mater. 184, 515-522.
- Conference Proceedings:
  - Chang, Q.G.; Lin, W. (2010) Impacts of amount of impregnated iron in granular activated carbon on arsenic adsorption capacities and kinetics. Proc. of 83rd WEFTEC, New Orleans, Louisiana, U.S.A., 282-299.
- Other Publications:
  - Chang, Q.G. and Lin, W. Arsenic Adsorption on Iron Impregnated Granular Activated Carbon: Isotherm and Breakthrough. Presented at the 81st ND WPCC, Fargo, ND, Oct 12th, 2010;
  - Chang, Q.G. and Lin, W. Impacts of the Amount of Impregnated Iron in GAC on Arsenic Adsorption Capacities and Kinetics. Presented at the 83rd WEFTEC, New Orleans, LA, Oct 4th, 2010;
  - Chang, Q.G. and Lin, W. pH impact on As(III) and As(V) Adsorption Using Fe-GACs. Presented at the 3rd International Student Prairie Conference-Environmental Issue. University of Manitoba, Winnipeg, CA, June 8th, 2010;

Report Follows

Iron-Impregnation Granular Activated Carbon for Arsenic Removal from Drinking Water

Modification of Fe-GAC synthesis method and adsorption studies

The multi-step iron impregnation method was further modified to improve the impregnation efficiency and the arsenic adsorption properties. Using GAC Darco 20×50, iron content 28.90% (by weight) of iron was successfully impregnated inside GAC stably and evenly. This modification improved the impregnation efficiency approximately 100%. Arsenic adsorption isotherm tests were conducted using Fe-GACs with iron content of 4.56-28.90% at low arsenic concentration (<250µg/L). Langmuir model fits arsenic adsorption very well. The maximum arsenic adsorption capacity increased with impregnation iron up to 13.59% and then slowly decreased with further increase of iron content. BET analysis found that both surface area and pore volume of Fe-GACs decreased with impregnated iron. It was found that the BET surface area of impregnated iron reaches the maximum at the iron content of 13.59%. Unlike the arsenic maximum adsorption capacity that was affected significantly by iron content, the affinity of Fe-Fe-GAC for arsenic was not affected by the iron content, which is 0.0223 L/µg for As(V) and 0.0170 L/µg for As(III).

Arsenic adsorption kinetics

A new second-order kinetics model was developed to investigate the impact of the amounts of impregnated iron on arsenic adsorption kinetics. This new kinetics model can well fit arsenic adsorption kinetics. With iron content increase from 1.64% to 28.90%, the intrinsic adsorption rate constants kept reducing from 4.6×10^{-2} 1/hr to 1.18×10^{-3} 1/hr, which indicates that impregnated iron slows arsenic intraparticle diffusion rate in Fe-GAC. Decreased arsenic intraparticle diffusion rate was most likely caused by reduced pore size of Fe-GACs. The intrinsic adsorption rate constant is independent on initial arsenic loading in kinetics tests, which eases the comparison of the arsenic adsorption kinetics of Fe-GACs.

Environmental implications

The groundwater sample was taken from the former Arsenic Trioxide Superfund site (Site ID #0800522) in southeastern North Dakota for evaluation of the potential implementations of Fe-GACs. The average arsenic concentration in the groundwater sample is 205 µg/L and the groundwater was spiked with As(V) to obtain an initial arsenic concentration of 3000 µg/L for isotherm tests. No other modification to the groundwater sample was made. Fe-GACs can effectively remove arsenic from the groundwater to meet 10 µg/L regulation and the arsenic adsorption capacity was enhanced greatly with impregnated iron. Compared with As(III) and As(V) synthetic water, Fe-GACs exhibited the approximately same maximum adsorption capacity for groundwater, which is reasonable because the maximum adsorption capacity is determined by the density of adsorption sites of Fe-GACs. However, the affinity of Fe-GACs for groundwater (0.0073 L/µg) is much less than these for As(III) and As(V) synthetic water. The presence of a large amount of phosphate in groundwater probably explains the lower affinity for arsenic. Due to the similar molecular structure with arsenic, phosphate is the most competing anion with arsenic on iron-based adsorbents.