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Experimental Investigations and Theoretical Modeling Aspects in Column Studies for Removal of Cr(VI) from Aqueous Solutions Using Activated Tamarind Seeds

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ABSTRACT

Continuous adsorption experiments are conducted using fixed-bed adsorption column to evaluate the performance of the adsorbent developed (from activated tamarind seeds) for the removal of Cr(VI) from aqueous solutions and the results obtained are validated with a model developed in this study. The effects of significant parameters such as flow rate, mass of adsorbent, and initial Cr(VI) concentration are studied and breakthrough curves are obtained. As the flow rate increases from 10 to 20 mL min-1, the breakthrough time decreases from 210 to 80 min. As the mass of adsorbent increases, breakthrough time gets delayed. The breakthrough times are obtained as 110, 115 and 210 min for 15, 20 and 25 g of activated tamarind seeds. As the initial Cr(VI) concentration increases from 100 to 200 mgL-1, the break point time decreases from 210 to 45 min. The process parameters for fixed-bed adsorption such as breakthrough time, total percentage removal of Cr(VI), adsorption exhaustion rate and fraction of unused bed length are calculated and the performance of fixed-bed adsorption column is analyzed. The mechanism for Cr(VI) adsorption on activated tamarind seeds is proposed. At low value of solution pH (= 1), the increase in Cr(VI) adsorption is due to the electrostatic attraction between positively charged groups of activated tamarind seeds and the HCrO4-. A mathematical model for fixed-bed adsorption column is proposed by incorporating the effect of velocity variation along the bed length in the existing model. Pore and surface diffusion models are used to describe the intra-particle mechanism for Cr(VI) adsorption. The breakthrough curve obtained theoretically from pore diffusion model and surface diffusion model are compared with experimental results for different operating conditions. The standard deviation values obtained for pore diffusion model and solid diffusion model are 0.111 and 0.214 respectively.

KEYWORDS

Adsorption, Mathematical Modeling, Intraparticle Mechanism, Activated Tamarind Seeds, Hexavalent Chromium

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References

[1] C. Namasivayam and R. T. Yamuna, "Adsorption of Chromium(VI) by a Low-Cost Adsorbent: Biogas Resi-dual Slurry," Chemosphere, Vol. 30, No. 3, 1995, pp. 561-578.

[2] R. Kumar, N. R. Bishnoi and G. K. Bishnoi, "Biosorption of Chromium(VI) from Aqueous Solution and Electrop-lating Wastewater Using Fungal Biomass," Chemical Engineering Journal, Vol. 135, No. 3, 2007, pp. 202-208.

[3] E. Malkoc and Y. Nuhoglu, "Potential of Tea Factory Waste for Chromium(VI) Removal from Aqueous Solu-tions: Thermodynamic and Kinetic Studies," Separation & Purification Technology, Vol. 54, No. 2, 2007, pp. 291-298.

[4] Agency for Toxic Substances and Disease Registry (ATSDR), "Toxicological Profile for Chromium," US

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Public Health Service, US Department of Health and Human Services, Altanta, 1993.

[5] M. Aliabadi, K. Morshedzadeh and H. Soheyli, "Removal of Hexavalent Chromium from Aqueous Solution by Lignocellulosic Solid Wastes," International Journal of Environmental Science & Technology, Vol. 3, No. 3, 2006, pp. 321-325.

[6] B. V. Babu and S. Gupta, "Adsorption of Cr(VI) Using Activated Neem Leaves as an Adsorbent: Kinetic Studies," Adsorption, Vol. 14, No. 1, 2008, pp. 85-92.

[7] B. V. Babu and S. Gupta, "Removal of Cr(VI) from Wastewater Using Activated Tamarind Seeds as an Ad-sorbent," Journal of Environmental Engineering and Science, Vol. 7, No. 5, 2008, pp. 553-557.

[8] E. Alvarez-Ayuso, A. Garcia-Sanchez and X. Querol, "Adsorption of Cr(VI) from Synthetic Solutions and Electroplating Wastewaters on Amorphous Aluminium Oxide," Journal of Hazardous Materials, Vol. 142, No. 1-2, 2007, pp. 191-198.

[9] S. Gupta and B. V. Babu, "Removal of Toxic Metal Cr(VI) from Aqueous Solutions Using Sawdust as Adsorbent: Equilibrium, Kinetics, and Regeneration Studies," Chemi-cal Engineering Journal, Vol. 150, No. 2-3, 2009, pp. 352-365.

[10] H. T. Liao and C. Y. Shiau, "Analytical Solution to an Axial Dispersion Model for the Fixed-Bed Adsorber," American Institute of Chemical Engineers Journal, Vol. 46, No. 6, 2000, pp. 1168-1176.

[11] A. Ramadevi and K. Srinivasan, "Agricultural Solid Waste for the Removal of Inorganics: Adsorption of Mercury (II) from Aqueous Solution by Tamarind Nut Carbon," Indian Journal of Chemical Technology, Vol. 12, No. 4, 2005, pp. 407-412.

[12] K. Selvaraj, S. Manonmani and S. Pattabhi, "Removal of Hexavalent Chromium Using Distillery Sludge," Biore-source Technology, Vol. 89, No. 2, 2003, pp. 207-211.

[13] S. M. Contreras-Ramos, D. Alvarez-Bernal, N. Trujillo- Tapia and L. Dendooven, "Composting of Tannery Ef-fluent with Cow Manure and Wheat Straw," Bioresource Technology, Vol. 94, No. 2, 2004, pp. 223-228.

[14] E. Malkoc, Y. Nuhoglu and Y. M. Dundar, "Adsorption of Chromium(VI) on Pomace-An Olive Oil Industry Waste: Batch and Column studies," Journal of Hazardous Materials, Vol. 138, No. 1, 2006, pp. 142-151.

[15] V. Sarin, T. S. Singh and K. K. Pant, "Thermodynamic and Breakthrough Column Studies for the Selective Sorp-tion of Chromium From Industrial Effluent on Activated Eucalyptus Bark," Bioresource Technology, Vol. 97, No. 16, 2006, pp. 1986-1993.

[16] American Public Health Association (APHA), "Standard Methods for the Examination of Water and Wastewater," 16th Edition, APHA, AWWA, WPCF, Washington, D.C, 1985.

[17] B. V. Babu and S. Gupta, "Modeling and Simulation of Fixed-Bed Adsorption Column: Effect of Velocity Varia-tion," Journal of Engineering Technology, Vol. 1, No. 1, 2005, pp. 60-66.

[18] Z. Aksu and F. D. G?nen, "Biosorption of Phenol by Immobilized Activated Sludge in a Continuous Packed Bed: Prediction of Breakthrough Curves," Process Bio-chemistry, Vol. 39, No. 5, 2004, pp. 599-613.

[19] S. Gupta and B. V. Babu, "Utilization of Waste Product (Tamarind Seeds) for the Removal of Cr(VI) from aqueous solutions: Equilibrium, Kinetics, and Regenera-tion Studies," Journal of Environmental Management, Vol. 90, No. 10, 2009, pp. 3013-3022.

[20] S. Gupta, "Theoretical and Experimental Investigations for Removal of Pollutants Using Adsorption," Doctoral Thesis, Birla Institute of Technology and Science, Pilani, 2008.