An Interdisciplinary Response to Mine Water Challenges - Sui, Sun & Wang (eds)

The Passive Treatment of Arsenic-containing Acid Mine Drainage and Using Manganese-coated Bone Char and Evaluation on its Neutralization Ability

Juan Liu, Dezheng Gao, Shiming Deng, Jing Liu
The Key Laboratory of Solid Waste Treatment and Resource, Ministry of Education, Southwest University of Science and Technology, 621010 Mianyang, China

Abstract The technologies of treating acid mine drainage (AMD) commonly include active and passive treatment. The coating technology can enhance the removal performance of some low-cost adsorbents. This study adopted Langmuir and Freundlich isotherm to fit the batch experimental dates. The results show that the Q_{max} of coated bone char could increase 78.83 times than uncoated bone char. However, the coated layer could reduce the neutralization ability of bone char. The comprehensive performances of adopting manganese-coated bone char to remediate AMD should be comprehensively evaluated based on the removal and neutralization effectiveness.
Keywords acid mine drainage, bone char, removal, neutralization ability

Introduction

The technologies of treating acid mine drainage (AMD) commonly includes active and passive treatment. Acid mine drainage (AMD) is one of the important sources of arsenic contamination of groundwater, which is mainly released from the oxidation of arsenic pyrite, arsenopyrite and a series of arsenic sulfide minerals. As reported the arsenate concentrations in AMD range 0.01-50 mg/L (Robinson 2010). It has been reported manganese-coated technology are: Manganese oxide coated filter media to remove of heavy metals, such as arsenic, copper, lead, cadmium and zinc (Chang 2007,Liu 2005, Zou 2006, Boonfueng 2006, Fan 2005, Piispanen 2010). Manganese-coated media have strong adsorption performance and oxidizability, it can be applied to a wide application range of pH.

However, there is no quantitative research about manganese coating layer adsorption and migration of arsenic. This study adopted bone char to neutralize AMD and remove arsenic using batch experiments. This study adopted Langmuir and Freundlich isotherm to fit the batch experimental dates and obtain the maximum adsorption capacity (Q_{max}) to qualify the removal performance of As (V).

Materials and methods

The bone char used in the preparation of manganese-coated bone char was taken from a biochemical company in Sichuan. The mineral composition of this bone char was identified to $Ca_5(PO_4)_3{\cdot}OH$ which based on X-ray diffraction (XRD) analysis.

Batch experiments were carried out in glass flasks (250 mL) using an orbital shaker at 25 ℃, at a constant agitation of 150 rpm. In the kinetic studies, suspensions were stirred for 48 h at an initial pH of 4. Supernatant aliquots were collected and filtered through a 0.22 μm filter before Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) analysis.

The neutralization ability of manganese-coated bone char experiments were carried out with Automated Potentiometric Instrument (T50, METTLER TOLEDO). The procedure as follows: Adding 50 mL distilled water which was adjusted to pH of 2 with 10% HNO_3, then add 0.5 g of manganese coated bone char, observe and record the changes values of pH interval of 30 seconds.

Results and discussion

X-ray diffraction and SEM micrograph of the manganese-coated bone char

The X-ray diffraction of fig. 1 shows that the comparative analysis of no-coated bone char and the maximum capacity of manganese-coated bone char (B7) and there are some containing manganese substances.

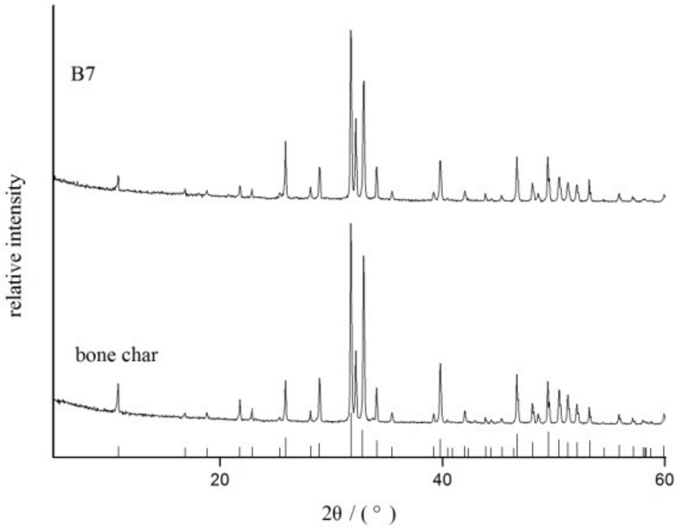

Fig.1 *XRD of the bone char and manganese-coated bone char*

Micrographs shown in fig. 2 were taken at 20000× magnification to observe the changes of bone char surface morphology by manganese deposition. It can be clearly found in fig. 2 that the no-coated bone char have loose and porous nature, and the surface of manganese-coated bone char is covered by manganese-containing particles, this coating gradually develops with the initial Mn concentrations. The surface of B7 are formed the coating layer. The results of Energy Disperse Spectroscopy (EDS) show that these nanometer particles only have manganese.

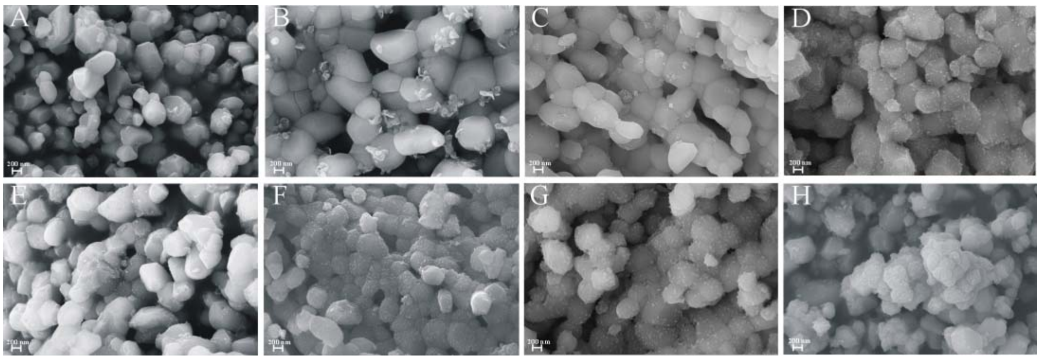

Fig.2 *SEM micrographs of the particles of the manganese-coated bone char (A. B0, B. B1, C. B2, D. B3, E. B4, F. B5, G. B6, H. B7. The detailed numbers are given in table 1.)*

Adsorption isotherms

Several mathematical models have been proposed to describe the equilibrium isotherms of adsorption process. The most popular models are Langmuir and Freundlich for single and binary cases.

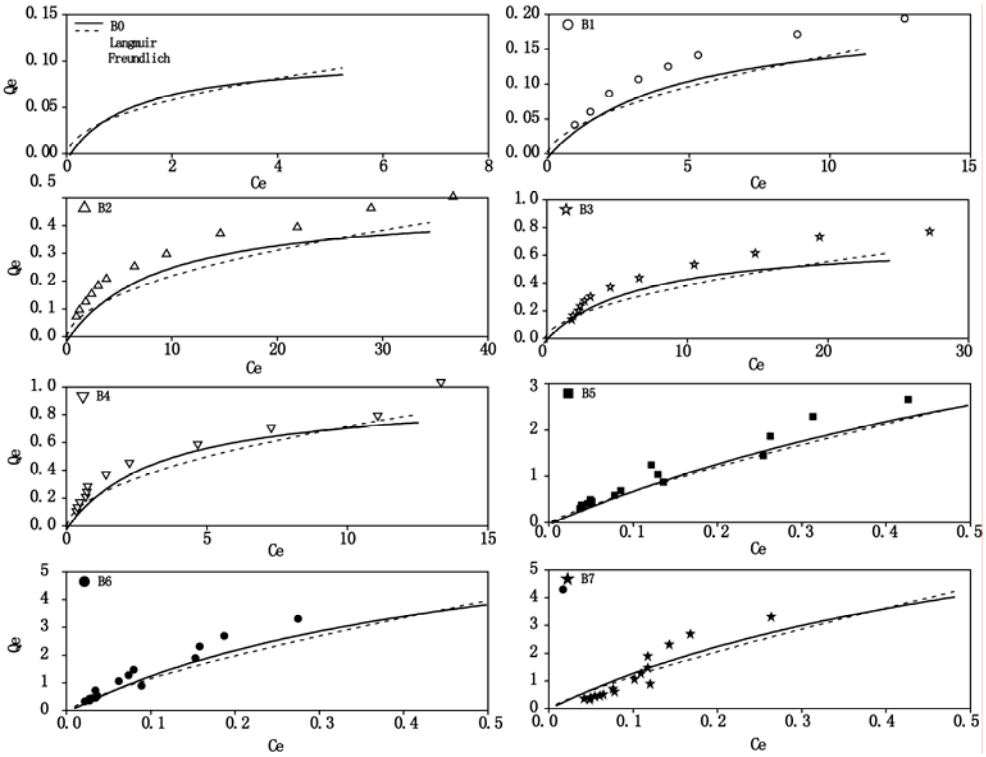

Fig. 3 *As (V) adsorption isotherms onto manganese-coated bone char*

Fig.3 shows the As (V) adsorption isotherms onto manganese-coated bone char. The values of the constants in the models and correlation coefficients obtained are summarized in table 1. The Langmuir parameters equation, Q_{max}, represents the monolayer saturation at equilibrium. The maximum adsorption capacity calculated base on Langmuir model is reaches 0.12 mg/g for no-coated bone char (B0). It increases to 0.21, 0.50, 0.77, 0.94, 7.55, 7.75 mg/g, even as high as 9.46 mg/g for B1, B2, B3, B4, B5, B6, B7, respectively. It can be seen that the coating amount of manganese increases, the maximum amount of adsorption also increased.

Using Minitab software to compare the results of two equations fit, the P (0.781) of reaction coefficient calculated from Langmuir and Freundlich was statically determined to be greater than 0.005, there is no significant difference existing in two models, which indicate Langmuir and Freundlich models both are feasible to describe the adsorption behavior of arsenic on Manganese coated bone char.

Table 1 *Parameters calculated of two models for isotherm adsorption*

Mn-coated bone char	Langmuir model				Freundlich model		
	Q_{max}	$\triangle Q$	K	R^2	K	n	R^2
no-coated bone (B0) char B0	0.12	--	0.80	0.80	0.05	0.44	0.79
0.4g/L Mn-coated (B1)	0.21	0.10	0.23	1.00	0.05	0.52	0.99
2g/L Mn-coated (B2)	0.50	0.39	0.11	0.98	0.08	0.48	0.99
4g/L Mn-coated (B3)	0.77	0.65	0.15	0.98	0.13	0.50	0.99
8g/L Mn-coated (B4)	0.94	0.82	0.35	0.93	0.24	0.48	0.94
15g/L Mn-coated (B5)	7.55	7.44	1.06	0.97	4.57	0.80	0.97
25g/L Mn-coated (B6)	7.75	7.64	2.06	0.96	6.80	0.74	0.93
30g/L Mn-coated (B7)	9.46	9.35	1.60	0.89	7.73	0.81	0.86

The neutralization evaluation

As seen from fig. 4 the coated layer could reduce the neutralization ability of bone char, which the final pH value of equilibrium solution becomes 4.66 (B7) compared to that of 6.07 by no-coated bone char (B0).

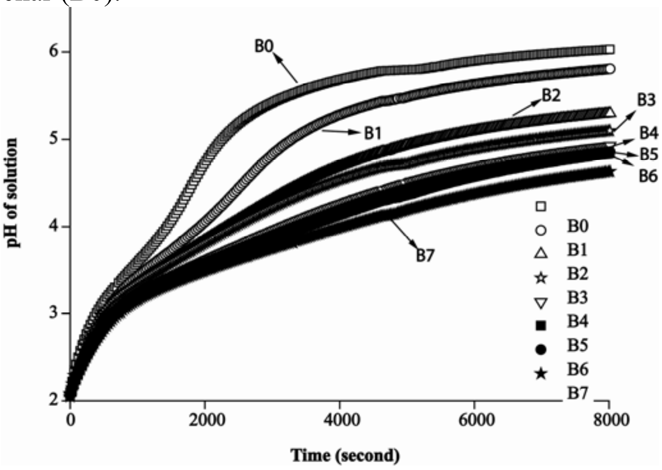

Fig. 4 *The neutralization ability of manganese-coated bone char*

Conclusions

This study have found that the surface of manganese-coated bone char covered containing manganese particles, this coating gradually develops with the initial Mn concentrations. Langmuir and Freundlich isotherm fit very well in the batch experimental data and obtain the maximum adsorption capacity (Q_{max}) to qualify the removal performance of As (V). The results show that the Q_{max} of coated bone char could increase 78.83 times than no-coated bone char. However, the coated layer could reduce the neutralization ability of bone char, which the final pH value of equilibrium solution reduce to 4.66 compared to that of 6.07 by no-coated bone char.

Acknowledgements

This work was supported by National Natural Science Foundation of China (No. 41372051) and the Opening Project of State Key Laboratory of Coal Resources and Safe Mining, China University of Mining & Technology (SKLCRSM13KFB03).

References

Boonfueng Thipnakarin, Axe Lisa, Xu Y, et al (2006) The impact of Mn oxide coatings on Zn distribution. Journal of colloid and interface science 298(2): 615-623

Chang YY, Kim KS, Jung JH, et al (2007) Application of iron-coated sand and manganese-coated sand on the treatment of both As(III) and As(V). Water Science and Technology 55(1-2): 69

Fan HJ ,Anderson Paul R (2005) Copper and cadmium removal by Mn oxide-coated granular activated carbon. Separation and purification technology 45(1): 61-67

Liu DF, Sansalone John J ,Cartledge Frank K (2005) Comparison of sorptive filter media for treatment of metals in runoff. Journal of Environmental engineering 131(8): 1178-1186

Piispanen JK ,Sallanko JT (2010) Mn (II) removal from groundwater with manganese oxide-coated filter media. Journal of Environmental Science and Health Part A 45(13): 1732-1740

Robinson BC (2010) Mine drainage and related problems. New York:Nova Science Publisher, Inc 1-69

Zou WH, Han RP, Chen ZZ, et al (2006) Characterization and properties of manganese oxide coated zeolite as adsorbent for removal of copper (II) and lead (II) ions from solution. Journal of Chemical and Engineering Data 51(2): 534-541