FIXED BED COLUMN STUDY FOR CAFFEINE REMOVAL FROM WASTEWATER USING GRANULAR ACTIVATED CARBON

S. Álvarez, J. L. Sotelo, A. Rodríguez, J. García
Department of Chemical Engineering – Catálisis y Procesos de Separación
Universidad Complutense de Madrid.
satorrellas@quim.ucm.es

ABSTRACT

Liquid phase adsorption of caffeine in fixed beds of granular activated carbon was investigated. This carbon material was found to be an efficient media for the removal of caffeine. The column having a diameter of 6 mm and 30 cm length, with different bed depths such as 6, 8 and 10 cm could treat 2.0 and 3.0 ml/min bearing wastewater with initial caffeine concentrations of 10 mg/l and 15 mg/l. Several column design parameters like adsorption capacities at breakthrough and saturation times, height of the mass transfer zone, fractional bed utilization were calculated. Also, the effect of flow rate and initial concentration was studied. Excellent agreement between simulated results and experimental data was obtained.

EXPERIMENTAL METHOD

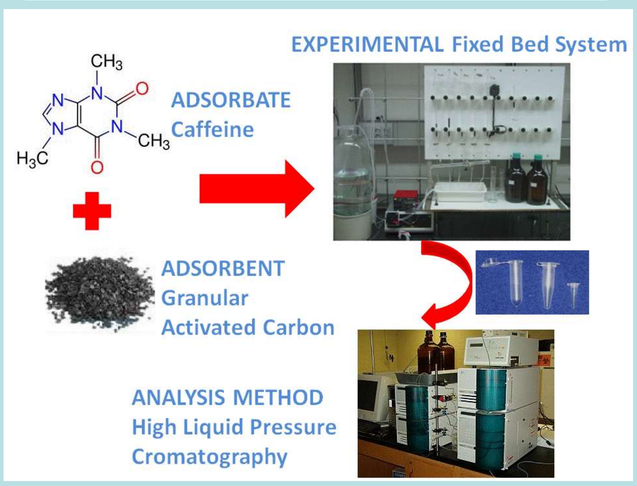

Table 1. Operation conditions in fixed bed column experiments.

Case	Initial concentration ($mg.L^{-1}$)	Bed depth (cm)	Bed weight (g)	Volumetric flow rate ($mL.min^{-1}$)
1	15.0	6.0, 8.0 and 10.0	0.6, 0.8 and 1.0	3.0
2	10.0 and 15.0	8.0	0.8	2.0
3	15.0	8.0	0.8	2.0 and 3.0

RESULTS AND CONCLUSIONS

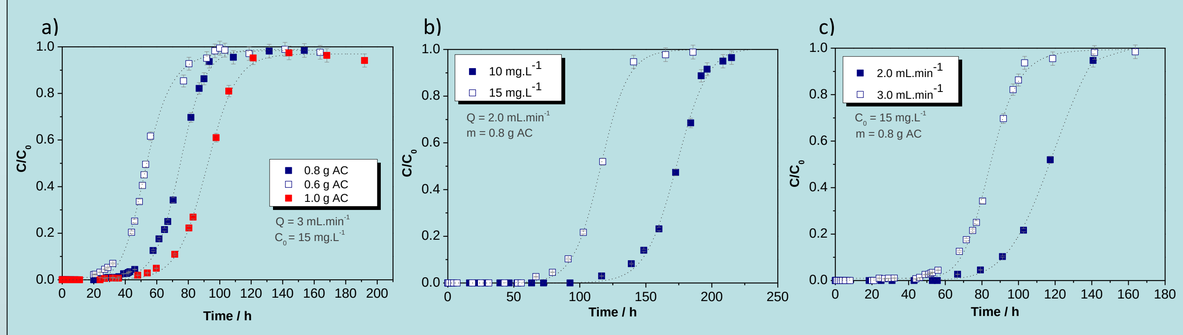

Fig. 1. Breakthrough curves of caffeine removal by granular activated carbon packed columns of a) different bed weights (initial caffeine conc. = 15.0 $mg.L^{-1}$, flow rate = 3.0 $mL.min^{-1}$). b) Different initial concentrations (bed weight. = 0.8 g, flow rate = 2.0 $mL.min^{-1}$). c) Different flow rates (bed weight. = 0.8 g, initial caffeine conc. = 15.0 $mg.L^{-1}$).

RESULTS AND CONCLUSIONS

Table 2. Adsorption capacities (q_r, q_s), MTZ and FBU. Caffeine. Case 1, 2 and 3.

Parameter	Bed depth (cm) (Case 1)			Initial concentration ($mg.L^{-1}$) (Case 2)		Flow rate ($mL.min^{-1}$) (Case 3)	
	6 (*)	8 (*)	10 (*)	10.0	15.0	2.0	3.0
q_S (mg caffeine/gGAC)	239.8	247.4	224.9	252.1	255.4	241.7	280.4
q_r (mg caffeine/gGAC)	125.4	151.7	150.3	171.9	147.5	141.9	184.6
MTZ (cm)	2.86	3.10	3.32	2.55	3.38	3.30	2.73
FBU	0.52	0.61	0.67	0.68	0.58	0.59	0.66

(*) Bed depths are equivalent to these bed weights, respectively: 0.6, 0.8 and 1.0

Table 3. Overall mass transfer coefficients.

		Conditions	K_La (h^{-1})
Case 1	L	6 cm	1168.0
		8 cm	1206.9
		10 cm	1012.2
Case 2	C_0	10 $mg.L^{-1}$	1093.2
		15 $mg.L^{-1}$	759.2
Case 3	Q	2.0 $mL.min^{-1}$	759.2
		3.0 $mL.min^{-1}$	1090.1

CONCLUSIONS

The present investigation illustrates that fixed bed column adsorption of caffeine on granular activated carbon could be an interesting and effective treatment for the removal of this micropollutant from waters. The adsorption process of caffeine in the fixed bed was strongly dependent on the flow rate, initial concentration and bed height. It is found that the breakthrough time decreases with the flow rate and initial concentration increase, and with the bed depth decrease.

Parameters as adsorption capacity at breakthrough time (q_r) and saturation time (q_s), MTZ and FBU were obtained for different conditions. It was found that the best results of MTZ and FBU correspond to the higher flow rate, and is about constant with bed depth. Additionally, this study confirms that the overall coefficient of mass transfer increases with increasing water flow rate.

Acknowledgements.-The authors gratefully acknowledge the financial support from Ministerio de Educación y Ciencia by CONSOLIDER Program through TRAGUA Network CSD2006-44, CTQ2008-02728 and by Comunidad de Madrid through REMTAVARES Network S2009/AMB-1588.

Programa REMTAVARES S2009/AMB-1588
UNION EUROPEA
FONDO SOCIAL