ADSORPTION AND BIOLOGICAL FILTRATION OF MICROCYSTINS

By

Haixiang Wang

School of Chemical Engineering
The University of Adelaide
Australia

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Abstract

For removal of microcystins (liver tumor promoting cyanotoxins) from drinking water granular activated carbon (GAC) filtration has been shown to be a very promising treatment option. It is not only an efficient adsorbent for microcystins but also can be operated as a biological reactor in which bacterial degradation of the toxins can occur extending the life-time of this application.

However, the competitive adsorption of coexistent natural organic matter (NOM) in all natural water sources would cause early breakthrough of microcystins and a lag-phase with uncertain length occurs prior to initiation of biodegradation. This project aimed to investigate the individual microcystin removal abilities by adsorption and biodegradation during GAC filtration in order to better understand the overall efficiency of this application. The simultaneous elimination of NOM in GAC filters was also investigated. In addition, to facilitate the biological removal of microcystins, the research aimed to identify the potential effect of key operational conditions on the degradation efficiency.

In this study microcystin removal in GAC filtration was divided into the adsorption and biodegradation phases. Effective adsorption of the toxins lasted only a short term in virgin GAC filters and the breakthrough behaviour was able to be modelled by the homogenous surface diffusion model (HSDM). The presence of biofilm on the surfaces of GAC resulted in a lower mass transfer coefficient (K_f) and lower adsorption kinetics of microcystins. In the biodegradation phase enhanced or complete removal was evident that was mainly due to biological metabolism. However, the highly efficient biodegradation of the toxins was difficult to predict in GAC filtration. Biodegradation was found to be easily affected by many operational factors.

NOM removal in GAC filters demonstrated specific features in this study due to the relatively high organic content in the Australian water. The adsorption efficiency decreased rapidly as the adsorption capacity became saturated.

Statement of Originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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List of Publications

Haixiang W., Lewis D. M., Brookes J. B., Newcombe G. and Lionel H. (2005) Combined adsorption and biodegradation of microcystins (Poster Presentation). The 10th International Conference in Applied Phycology. July 2005.

Haixiang W., Brookes J. B., Lewis D. M., Newcombe G. and Lionel H. (2006) Adsorption and biodegradation of microcystins in GAC filtration. In Proceedings of the 1st Australian Young Water Professionals Conference, Sydney, Australia. February 2006.

Haixiang W., Lewis D. M., Brookes J. B. and Newcombe G. (2006) Removal of microcystins in GAC filtration. In Proceedings of the Fifth Biennial Postgraduate Student Conference of the CRC for Water Quality and Treatment, Melbourne, Australia. July 2006.

Haixiang W., Lewis D. M., Brookes J. B., Newcombe G. and Lionel H. (2006) Separated adsorption and bacterial degradation of microcystins in GAC filtration. In Proceedings of the CHEMECA Conference, Auckland, New Zealand. September 2006. In press.

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Glossary of Abbreviations and Acronyms

AC	Activated carbon
Adda	3-amino-9-methoxy-2,6,8-trimethyl-10 phenyldeca -4,6-dienoic acid
BGAC	Biological granular activated carbon
DOC	Dissolved organic carbon
EBCT	Empty bed contact time
GAC	Granular activated carbon
HPLC	High performance liquid chromatography
HPSEC	High performance size exclusion chromatography
HSDM	Homogenous surface diffusion model
K_f	Film mass transfer coefficient
m-LA	Microcystin-LA
m-LR	Microcystin-LR
MW	Molecular weight
NOM	Natural organic material
PAC	Powdered activated carbon
SEM	Scanning electron microscopy
UV	Ultraviolet
UVA_{254}	Ultraviolet absorbance at 254nm wavelength
WTP	Water treatment plant
TCE	Trichloroethylene
THMs	Trihalomethanes