ELSEVIER

Water Research 39 (2005) 264–268

WATER RESEARCH

www.elsevier.com/locate/watres

Comment

Comment on "Removal of chlorophenols from groundwater by chitosan sorption"

Recently, Zheng et al. (2004) published the paper entitled as above. In Section 3, Sorption isotherms and kinetic models, two kinetic models, pseudo-first and pseudo-second order equations were used to analyze the mass transfer efficiency between chitosan and solute. Authors cited Wu et al. (2001) for these two models. In fact, it is Lagergren (1898) who first presented the first order rate equation for the adsorption of ocalic acid and malonic acid onto charcoal. Lagergren's kinetics equation has been most widely used for the adsorption of an adsorbate from an aqueous solution. In order to distinguish kinetics equation based on adsorption capacity of solid from the concentration of solution, Lagergren's first order rate equation has been called pseudo-first order since 1998 (Ho and McKay, 1998a, b, c, d). In addition, citation review of Lagergren kinetic rate equation on adsorption reactions has also been presented (Ho, 2004a). The second order kinetic expression for the adsorption systems of divalent metal ions using sphagnum moss peat has been reported by Ho (1995). In order to distinguish kinetics equation based on adsorption capacity of solid from the concentration of solution, Ho's second order rate expression has been named pseudo-second order (Ho, 1995, 2003a, b, c, d, 2004b, c; Ho and Chiang, 2001; Ho and McKay, 1997, 1998a, b, c, d, e, f, 1999a, b, c, d, 2000; Ho and Wang, 2004; Ho et al., 1996, 2000, 2001a, b, 2004). The earlier application of the pseudo-second order equation to the kinetic studies of competitive heavy metal adsorption by sphagnum moss peat was undertaken by Ho et al. (1996). In addition, a modified pseudo-second order kinetic expression has been reported since 1997 (Ho and McKay, 1997). The model has also been presented in following years (Ho, 2002, 2003a, b, c, d, 2004b, c; Ho and Chiang, 2001; Ho and McKay, 1998a, b, c, d, e, f, 1999a, b, c, d, 2000; Ho and Wang, 2004; Ho et al., 2000, 2001a, b, 2004). The most frequently cited papers were published in *Environmental Technology* (Ho et al., 1996), *Process Safety and Environmental Protection* (Ho and McKay, 1998a, b), *Chemical Engineering Journal* (Ho and McKay, 1998c), *Journal of Environmental Science and Health Part A-Toxic/Hazardous Substances & Environmental Engineering* (Ho and McKay, 1999a) *Resources*, *Conservation and Recycling* (Ho and McKay, 1999b), *Process Biochemistry* (Ho and McKay, 1999c) and *Water Research* (Ho and McKay, 2000). Similar comments have also been published in *Adsorption Science & Technology* (Ho, 2002), *Journal of Colloid and Interface Science* (Ho, 2003a, 2004b), *Journal of Chemical Technology and Biotechnology* (Ho, 2003b), *Biochemical Engineering Journal* (Ho, 2003c), and *Bioresource Technology* (Ho, 2004c).

The pseudo-second order rate expression of Ho has been widely applied to the sorption of metal ions, dyes, herbicides, oil and organic substances from aqueous solutions (Table 1). Moreover, discussion of the reaction order has been reported, for example, the comparison of chemisorption kinetic models (Ho and McKay, 1998a), and pseudo-second order model (Ho and McKay, 1999c). Furthermore, Ho's kinetic expression has also been applied to a multi-stage batch sorption design (Ho and McKay, 1998e, 1999d) and pseudo-isotherm studies (Ho and Wang, 2004).

Research papers conventionally include an introduction, a description of the objectives and procedures of the study, an account of the results and a discussion of the results and their implications. However, a paper's contribution exists not only in its originality and creativity, but also in its continuity and development for the following researches. The reference section can play a key role to researchers who were interested in the paper's statement and would like to follow the study or find useful information from the paper (Ho, 2004a). I suggest that Zheng et al. cite Ho's original pseudo-second order kinetic expression paper or relevant works.

0043-1354/$ - see front matter
doi:10.1016/j.watres.2004.07.018

Table 1
Pseudo-second order kinetic model of various related systems from the literature

Sorbent	Sorbate	References
2-Mercaptobenzimidazole–clay	Hg(II)	(Manohar et al., 2002)
Activated carbon	Hg(II)	(Krishnan and Anirudhan, 2002a)
Activated carbon	Pb(II), Hg(II), Cd(II), Co(II)	(Krishnan and Anirudhan, 2002b)
Activated carbon	Cd(II)	(Krishnan and Anirudhan, 2003)
Activated carbon	Pb(II)	(Krishnan et al., 2003)
Activated carbon	Methylene blue	(Banat et al., 2003a)
Activated carbon	Cd(II)	(Özer and Tümen, 2003)
Activated carbon	Phenol	(Banat et al., 2004)
Activated carbon	Cd(II), Ni(II)	(Basso et al., 2002)
Activated carbon	2,4-dichlorophenoxy-acetic acid (2,4-D)	(Aksu and Kabasakal, 2004)
Activated clay	Basic red 18, Acid blue 9	(Ho et al., 2001b)
Aspergillus niger	Pb(II), Cd(II), Cu(II), Ni(II)	(Kapoor et al., 1999)
Aspergillus niger	Basic blue 9	(Fu and Viraraghavan, 2000)
Aspergillus niger	Acid blue 29	(Fu and Viraraghavan, 2001)
Aspergillus niger	Congo red	(Fu and Viraraghavan, 2002)
Baker's yeast	Cd(II)	(Vasudevan et al., 2003)
Banana stalk [*Musa paradisiaca*]	Hg(II)	(Shibi and Anirudhan, 2002)
Base-treated juniper fiber	Cd(II)	(Min et al., 2004)
Beech leaves	Cd(II)	(Ho and McKay, 1999c)
Bi_2O_3	Cr(VI)	(Ho and McKay, 1999c)
Blast furnace slag, dust, sludge, Carbon slurry	Phenols	(Jain et al., 2004)
Bottom ash	Cu(II) and Pb(II)	(Ho and McKay, 1999c)
Calcined alunite	Phosphorus	(Özacar, 2003)
Calcined Mg-Al-CO_3 hydrotalcite	Cr(VI)	(Lazaridis and Asouhidou, 2003)
Chitin, chitosan, *Rhizopus arrhizus*	Cr(VI), Cu(II)	(Sağ and Aktay, 2002)
Coir	Cu(II), Pb(II)	(Quek et al., 1998a)
Coir pith carbon	Congo red	(Namasivayam and Kavitha, 2002)
Cypress leaves	Pb(II)	(Ho and McKay, 1999c)
Date pits	Methylene blue	(Banat et al., 2003b)
Diatomaceous earth	Methylene blue	(Shawabkeh and Tutunji, 2003)
Fly ash	Omega chrome red ME, *o*-cresol, *p*-nitrophenol	(Ho and McKay, 1999a)
Fly ash	Victoria blue, OCL, PNP, OCRME	(Ho and McKay, 1999c)
Grafted silica	Pb(II), Cu(II)	(Chiron et al., 2003)
Iron oxide-coated sand	As(V), As(III)	(Thirunavukkarasu et al., 2003)
Microcystis	Ni(II), Cr(VI)	(Singh et al., 2001)
Microporous titanosilicate ETS-10	Pb(II)	(Zhao et al., 2003)
Mixed clay/carbon	Acid blue 9	(Ho and Chiang, 2001)
Mucor rouxii	Pb(II), Cd(II), Ni(II), Zn(II)	(Yan and Viraraghavan, 2003)
Myriophyllum spicatum	Pb(II), Zn(II), Cd(II)	(Keskinan et al., 2003)
Na-bentonite	Oil	(Viraraghavan and Moazed, 2003)
Peat	Basic blue 69, Acid blue 25	(Ho and McKay, 1999c)
Peat	Cu(II)	(Gundogan et al., 2004)
Peat	Cu(II)	(Petroni et al., 2004)
Peat	Cu(II)	(Ho and McKay, 1999c)
Peat-resin particle	Basic magenta, basic brilliant green	(Sun and Yang, 2003)
Perlite	Cd(II)	(Mathialagan and Viraraghavan, 2002)
Phosphate	Aluminum-impregnated mesoporous	(Shin et al., 2004)
Pith	Basic red 22, acid red 114	(Ho and McKay, 1999a)
Reed leaves	Cd(II)	(Ho and McKay, 1999c)
Rhizopus oligosporus	Cu(II)	(Beolchini et al., 2003)
Sago	Cu(II), Pb(II)	(Quek et al., 1998b)
Sawdust	Cd(II), Pb(II)	(Taty-Costodes et al., 2003)
Sawdust	Phenol	(Jadhav and Vanjara, 2004)

Table 1 (*continued*)

Sorbent	Sorbate	References
Schizomeris leibleinii	Pb(II)	(Özer, 2003)
Spent grain	Pb(II), Cd(II)	(Low et al., 2000)
Sphagnum moss peat	Cu(II), Ni(II)	(Ho et al., 1996)
Sphagnum moss peat	Chrysoidine (BO2), Astrazon blue (BB3), Astrazone blue (BB69)	(Ho and McKay, 1998d)
Sphagnum moss peat	Cu(II), Ni(II), Pb(II)	(Ho and McKay, 2000)
Sugar beet pulp	Pb(II), Cu(II), Zn(II), Cd(II), Ni(II)	(Reddad et al., 2002)
Sugar beet pulp	Pb(II)	(Reddad et al., 2004)
TNSAC	Phosphate	(Ho and McKay, 1999c)
Tree fern	Cd(II)	(Ho and McKay, 1999d)
Tree fern	Cu(II)	(Ho, 2003d)
Tree fern	Pb(II)	(Ho et al., 2004)
Vermiculite	Cd(II)	(Mathialagan and Viraraghavan, 2003)
Waste tyres, sawdust	Cr(VI)	(Hamadi et al., 2001)
Wollastonite	Ni(II)	(Ho and McKay, 1999c)
Wood	Basic blue 69, acid blue 25	(Ho and McKay, 1998b)

References

Aksu, Z., Kabasakal, E., 2004. Batch adsorption of 2,4-dichlorophenoxy-acetic acid (2,4-D) from aqueous solution by granular activated carbon. Sep. Purif. Technol. 35 (3), 223–240.

Banat, F., Al-Asheh, S., Makhadmeh, L., 2003a. Preparation and examination of activated carbons from date pits impregnated with potassium hydroxide for the removal of methylene blue from aqueous solutions. Adsorpt. Sci. Technol. 21 (6), 597–606.

Banat, F., Al-Asheh, S., Al-Makhadmeh, L., 2003b. Evaluation of the use of raw and activated date pits as potential adsorbents for dye containing waters. Process Biochem. 39 (2), 193–202.

Banat, F., Al-Asheh, S., Al-Makhadmeh, L., 2004. Utilization of raw and activated date pits for the removal of phenol from aqueous solutions. Chem. Eng. Technol. 27 (1), 80–86.

Basso, M.C., Cerrella, E.G., Cukierman, A.L., 2002. Activated carbons developed from a rapidly renewable biosource for removal of cadmium(II) and nickel(II) ions from dilute aqueous solutions. Ind. Eng. Chem. Res. 41 (2), 180–189.

Beolchini, F., Pagnanelli, F., Reverberi, A.P., Vegliò, F., 2003. Copper biosorption onto *Rhizopus oligosporus*: pH-edge tests and related kinetic and equilibrium modeling. Ind. Eng. Chem. Res. 42 (20), 4881–4887.

Chiron, N., Guilet, R., Deydier, E., 2003. Adsorption of Cu(II) and Pb(II) onto a grafted silica: Isotherms and kinetic models. Water Res. 37 (13), 3079–3086.

Fu, Y.Z., Viraraghavan, T., 2000. Removal of a dye from an aqueous solution by the fungus *Aspergillus niger*. Water Quality Res. J. Can. 35 (1), 95–111.

Fu, Y.Z., Viraraghavan, T., 2001. Removal of CI Acid Blue 29 from an aqueous solution by *Aspergillus niger*. AATCC Rev. 1 (1), 36–40.

Fu, Y., Viraraghavan, T., 2002. Removal of Congo Red from an aqueous solution by fungus *Aspergillus niger*. Adv. Environ. Res. 7 (1), 239–247.

Gundoğan, R., Acemioğlu, B., Alma, M.H., 2004. Copper(II) adsorption from aqueous solution by herbaceous peat. J. Colloid Inter. Sci. 269 (2), 303–309.

Hamadi, N.K., Chen, X.D., Farid, M.M., Lu, M.G.Q., 2001. Adsorption kinetics for the removal of chromium(VI) from aqueous solution by adsorbents derived from used tyres and sawdust. Chem. Eng. J. 81 (5), 95–105.

Ho, Y.S., 1995. Adsorption of heavy metals from waste streams by peat. Ph.D. Thesis, The University of Birmingham, Birmingham, UK.

Ho, Y.S., 2002. Comment on 'Removal of Ni^{2+} and Cu^{2+} ions from aqueous solutions on to lignite-based carbon', by S.E. Samra. Adsorpt. Sci. Technol. 20 (2), 199–201.

Ho, Y.S., 2003a. Comment on 'Adsorption of fluoride, phosphate, and arsenate ions on a new type of ion exchange fiber' by R.X. Liu, J.L. Guo, and H.X. Tang. J. Colloid Interface Sci. 262 (1), 307–308.

Ho, Y.S., 2003b. Letter to the editor. J. Chem. Technol. Biotechnol. 78 (6), 724.

Ho, Y.S., 2003c. Affinity dye-ligand poly(hydroxyethyl methacrylate)/chitosan composite membrane for adsorption lysozyme and kinetic properties G. Bayramoğlu, M. Yilmaz, M.Y. Arica. Biochem. Eng. J. 15 (1), 77–78.

Ho, Y.S., 2003d. Removal of copper ions from aqueous solution by tree fern. Water Res. 37 (10), 2323–2330.

Ho, Y.S., 2004a. Citation review of Lagergren kinetic rate equation on adsorption reactions. Scientometrics 59 (1), 171–177.

Ho, Y.S., 2004b. Comment on "An alternative Avrami equation to evaluate kinetic parameters of the interaction of Hg(II) with thin chitosan membranes, by E.C.N. Lopes, F.S.C. dos Anjos, E.F.S. Vieira, and A.R. Cestari. J. Colloid Interface Sci. 272 (1), 249–250.

Ho, Y.S., 2004c. Letter to the Editor "Kinetic modeling and equilibrium studies during cadmium biosorption by dead *Sargassum* sp. biomass" by Cruz, C.C.V., da Costa, A.C.A., Henriques, C.A., Luna, A.S., Bioresource Technol. 91(3), 93(3) (2003) 249–257, 321–323.

Ho, Y.S., Chiang, C.C., 2001. Sorption studies of acid dye by mixed sorbents. Adsorpt. J. Int. Adsorpt. Soc. 7 (2), 139–147.

Ho, Y.S., McKay, G., 1997. Pseudo kinetic model for sorption processes. In: Zhong, L., Zhenhua, Y. (Eds.), Advances in Adsorption Separation Science and Technology, The Proceedings of the Fourth China–Japan–USA Symposium on Advanced Adsorption Separation Science and Technology, May 13–16, 1997, Guangzhou, China, South China University of Technology Press, Guangzhou, pp. 257–263.

Ho, Y.S., McKay, G., 1998a. A comparison of chemisorption kinetic models applied to pollutant removal on various sorbents. Process Saf. Environ. Protection 76 (B4), 332–340.

Ho, Y.S., McKay, G., 1998b. Kinetic models for the sorption of dye from aqueous solution by wood. Process Saf. Environ. Protection 76 (B2), 183–191.

Ho, Y.S., McKay, G., 1998c. Sorption of dye from aqueous solution by peat. Chem. Eng. J. 70 (2), 115–124.

Ho, Y.S., McKay, G., 1998d. The kinetics of sorption of basic dyes from aqueous solution by sphagnum moss peat. Can. J. Chem. Eng. 76 (4), 822–827.

Ho, Y.S., McKay, G., 1998e. A two-stage hatch sorption optimized design for dye removal to minimum contact time. Process Saf. Environ. Protection 76 (B4), 313–318.

Ho, Y.S., McKay, G., 1998f. Kinetic model for lead(II) sorption on to peat. Adsorpt. Sci. Technol. 16 (4), 243–255.

Ho, Y.S., McKay, G., 1999a. Comparative sorption kinetic studies of dye and aromatic compounds onto fly ash. J. Environ. Sci. Health Part A-Toxic/Hazardous Subst. Environ. Eng. 34 (5), 1179–1204.

Ho, Y.S., McKay, G., 1999b. A kinetic study of dye sorption by biosorbent waste product pith. Resour. Conserv. Recycl. 25 (3–4), 171–193.

Ho, Y.S., McKay, G., 1999c. Pseudo-second order model for sorption processes. Process Biochem. 34 (5), 451–465.

Ho, Y.S., McKay, G., 1999d. A multi-stage batch sorption design with experimental data. Adsorpt. Sci. Technol. 17 (4), 233–243.

Ho, Y.S., McKay, G., 2000. The kinetics of sorption of divalent metal ions onto sphagnum moss peat. Water Res. 34 (3), 735–742.

Ho, Y.S., Wang, C.C., 2004. Pseudo-isotherms for the sorption of cadmium ion onto tree fern. Process Biochem. 39 (6), 759–763.

Ho, Y.S., Wase, D.A.J., Forster, C.F., 1996. Kinetic studies of competitive heavy metal adsorption by sphagnum moss peat. Environ. Technol. 17 (1), 71–77.

Ho, Y.S., McKay, G., Wase, D.A.J., Forster, C.F., 2000. Study of the sorption of divalent metal ions on to peat. Adsorpt. Sci. Technol. 18 (7), 639–650.

Ho, Y.S., Ng, J.C.Y., McKay, G., 2001a. Removal of lead(II) from effluents by sorption on peat using second-order kinetics. Separ. Sci. Technol. 36 (2), 241–261.

Ho, Y.S., Chiang, C.C., Hsu, Y.C., 2001b. Sorption kinetics for dye removal from aqueous solution using activated clay. Separation Sci. Technol. 36 (11), 2473–2488.

Ho, Y.S., Chiu, W.T., Hsu, C.S., Huang, C.T., 2004. Sorption of lead ions from aqueous solution using tree fern as a sorbent. Hydrometallurgy 73 (1–2), 55–61.

Jadhav, D.N., Vanjara, A.K., 2004. Removal of phenol from wastewater using sawdust, polymerized sawdust and sawdust carbon. I. J. Chem. Technol. 11 (1), 35–41.

Jain, A.K., Gupta, V.K., Jain, S., Suhas, 2004. Removal of chlorophenols using industrial wastes. Environ. Sci. Technol. 38 (4), 1195–1200.

Kapoor, A., Viraraghavan, T., Cullimore, D.R., 1999. Removal of heavy metals using the fungus *Aspergillus niger*. Bioresource Technol. 70 (1), 95–104.

Keskinkan, O., Goksu, M.Z.L., Yuceer, A., Basibuyuk, M., Forster, C.F., 2003. Heavy metal adsorption characteristics of a submerged aquatic plant (*Myriophyllum spicatum*). Process Biochem. 39 (2), 179–183.

Krishnan, K.A., Anirudhan, T.S., 2002a. Removal of mercury(II) from aqueous solutions and chlor-alkali industry effluent by steam activated and sulphurised activated carbons prepared from bagasse pith: kinetics and equilibrium studies. J. Hazardous Mater. 92 (2), 161–183.

Krishnan, K.A., Anirudhan, T.S., 2002b. Uptake of heavy metals in batch systems by sulfurized steam activated carbon prepared from sugarcane bagasse pith. Ind. Eng. Chem. Res. 41 (20), 5085–5093.

Krishnan, K.A., Anirudhan, T.S., 2003. Removal of cadmium(II) from aqueous solutions by steam-activated sulphurised carbon prepared from sugar-cane bagasse pith: kinetics and equilibrium studies. Water SA 29 (2), 147–156.

Krishnan, K.A., Sheela, A., Anirudhan, T.S., 2003. Kinetic and equilibrium modeling of liquid-phase adsorption of lead and lead chelates on activated carbons. J. Chem. Technol. Biotechnol. 78 (6), 642–653.

Lagergren, S., 1898. Zur theorie der sogenannten adsorption gelöster stoffe. Kungliga Svenska Vetenskapsakademiens. Handlingar, Band 24 (4), 1–39.

Lazaridis, N.K., Asouhidou, D.D., 2003. Kinetics of sorptive removal of chromium(VI) from aqueous solutions by calcined Mg-Al-CO_3 hydrotalcite. Water Res. 37 (12), 2875–2882.

Low, K.S., Lee, C.K., Liew, S.C., 2000. Sorption of cadmium and lead from aqueous solutions by spent grain. Process Biochem. 36 (1–2), 59–64.

Manohar, D.M., Krishnan, K.A., Anirudhan, T.S., 2002. Removal of mercury(II) from aqueous solutions and chlor-alkali industry wastewater using 2-mercaptobenzimidazole-clay. Water Res. 36 (6), 1609–1619.

Mathialagan, T., Viraraghavan, T., 2002. Adsorption of cadmium from aqueous solutions by perlite. J. Hazardous Mater. 94 (3), 291–303.

Mathialagan, T., Viraraghavan, T., 2003. Adsorption of cadmium from aqueous solutions by vermiculite. Sep. Sci. Technol. 38 (1), 57–76.

Min, S.H., Han, J.S., Shin, E.W., Park, J.K., 2004. Improvement of cadmium ion removal by base treatment of juniper fiber. Water Res. 38 (5), 1289–1295.

Namasivayam, C., Kavitha, D., 2002. Removal of Congo Red from water by adsorption onto activated carbon prepared from coir pith, an agricultural solid waste. Dyes Pigments 54 (1), 47–58.

Özacar, M., 2003. Equilibrium and kinetic modelling of adsorption of phosphorus on calcined alunite. Adsorp. J. Int. Adsorpt. Soc. 9 (2), 125–132.

Özer, A., 2003. Application of pseudo second order kinetic model to lead(II) biosorption on *Schizomeris leibleinii*. Fresen. Environ. Bull. 12 (10), 1239–1245.

Özer, A., Tümen, F., 2003. Cd(II) adsorption from aqueous solution by activated carbon from sugar beet pulp impregnated with phosphoric acid. Fresen. Environ. Bull. 12 (9), 1050–1058.

Petroni, S.L.G., Pires, M.A.F., Munita, C.S., 2004. Use of radiotracer in adsorption studies of copper on peat. J. Radioanal. Nucl. Chem. 259 (2), 239–243.

Quek, S.Y., Al Duri, B., Wase, D.A.J., Forster, C.F., 1998a. Coir as a biosorbent of copper and lead. Process Safety and Environmental Protection 76 (B1), 50–54.

Quek, S.Y., Wase, D.A.J., Forster, C.F., 1998b. The use of sago waste for the sorption of lead and copper. Water SA 24 (3), 251–256.

Reddad, Z., Gérente, C., Andres, Y., Le Cloirec, P., 2002. Adsorption of several metal ions onto a low-cost biosorbent: kinetic and equilibrium studies. Environ. Sci. Technol. 36 (9), 2067–2073.

Reddad, Z., Gerente, C., Andres, Y., Le Cloirec, P., 2004. Lead removal by a natural polysaccharide in membrane reactors. Water Sci. Technol. 49 (1), 163–170.

Sağ, Y., Aktay, Y., 2002. Kinetic studies on sorption of Cr(VI) and Cu(II) ions by chitin, chitosan and *Rhizopus Arrhizus*. Biochem. Eng. J. 12 (2), 143–153.

Shawabkeh, R.A., Tutunji, M.F., 2003. Experimental study and modeling of basic dye sorption by diatomaceous clay. Appl. Clay Sci. 24 (1–2), 111–120.

Shibi, I.G., Anirudhan, T.S., 2002. Synthesis, characterization, and application as a mercury(II) sorbent of banana stalk (*Musa paradisiaca*): Polyacrylamide grafted copolymer bearing carboxyl groups. Ind. Eng. Chem. Res. 41 (22), 5341–5352.

Shin, E.W., Han, J.S., Jang, M., Min, S.H., Park, J.K., Rowell, R.M., 2004. Phosphate adsorption on aluminum-impregnated mesoporous silicates: surface structure and behavior of adsorbents. Environ. Sci. Technol. 38 (3), 912–917.

Singh, S., Rai, B.N., Rai, L.C., 2001. Ni(II) and Cr(VI) sorption kinetics by *Microcystis* in single and multimetallic system. Process Biochem. 36 (12), 1205–1213.

Sun, Q.Y., Yang, L.Z., 2003. The adsorption of basic dyes from aqueous solution on modified peat-resin particle. Water Res. 37 (7), 1535–1544.

Taty-Costodes, V.C., Fauduet, H., Porte, C., Delacroix, A., 2003. Removal of Cd(II) and Pb(II) ions, from aqueous solutions, by adsorption onto sawdust of *Pinus sylvestris*. J. Hazardous Mater. 105 (1–3), 121–142.

Thirunavukkarasu, O.S., Viraraghavan, T., Subramanian, K.S., 2003. Arsenic removal from drinking water using iron oxide-coated sand. Water, Air, Soil Pollut. 142 (1–4), 95–111.

Vasudevan, P., Padmavathy, V., Dhingra, S.C., 2003. Kinetics of biosorption of cadmium on Baker's yeast. Bioresource Technol. 89 (3), 281–287.

Viraraghavan, T., Moazed, H., 2003. Removal of oil from water by bentonite. Fresen. Environ. Bull. 12 (9), 1092–1097.

Wu, F.C., Tseng, R.L., Juang, R.S., 2001. Enhanced abilities of highly swollen chitosan beads for color removal and tyrosinase immobilization. J. Hazard. Mater. 81 (1–2), 167–177.

Yan, G., Viraraghavan, T., 2003. Heavy-metal removal from aqueous solution by fungus *Mucor rouxii*. Water Res. 37 (18), 4486–4496.

Zhao, G.X.S., Lee, J.L., Chia, P.A., 2003. Unusual adsorption properties of microporous titanosilicate ETS-10 toward heavy metal lead. Langmuir 19 (6), 1977–1979.

Zheng, S.K., Yang, Z.F., Jo, D.H., Park, Y.H., 2004. Removal of chlorophenols from groundwater by chitosan sorption. Water Res. 38 (9), 2314–2321.

S.K. Zheng, Z.F. Yang, D.H. Jo, Y.H. Park, Yuh-Shan Ho

School of Public Health, Taipei Medical University, 250 Wu-Hsing Street, Taipei 11014, Taiwan

E-mail address: ysho@tmu.edu.tw