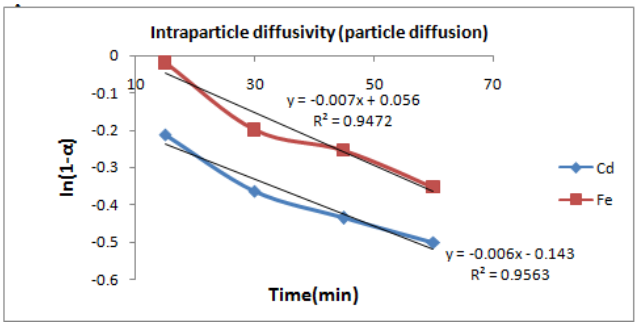

Figure 8: Intraparticle diffusivity (particle diffusion) plot for Cd (II) and Fe (III) ions adsorption on unmodified snail shell powder

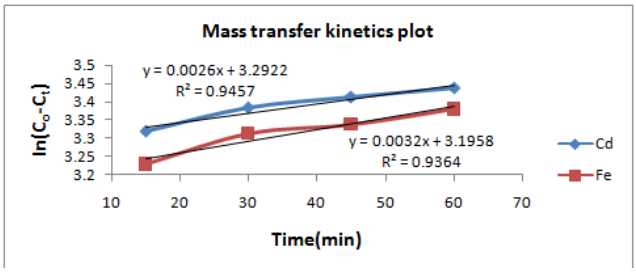

Figure 9: Mass transfer kinetics plot for Cd (II) and Fe(III) ions adsorption on unmodified snail shell powder

Table 1: Kinetics and diffusion parameters of adsorption of on unmodified snail shell powder

Type	*Parameters*	*Metal ion*	
		Cd^{2+}	Fe^{3+}
Pseudo -1ST Order	**q_e (mg/g)**	4.7315	6.4565
	K_1	2.203 x 10^{-3}	2.203 x 10^{-3}
	R^2	**0.9631**	**0.9551**
Pseudo -2ND Order	**q_e (mg/g)**	5.3763	4.9261
	K_2	2.256 x 10^{-2}	-2.792 x 10^{-1}
	R^2	**0.9917**	**0.9985**
Elovich	**α**	2665.9	9.4716
	β	1.5992	0.7011
	R^2	**0.9985**	**0.9842**
Mass transfer	**D**	26.902	24.4297
	K_0	2.6 x 10^{-3}	3.2 x 10^{-3}
	R^2	**0.9457**	**0.9364**
Intraparticle Diffusion (External film)	**K_i**	0.4479	0.5115
	X_i	-0.3331	-1.7613
	R^2	**0.9732**	**0.9732**
Intraparticle Diffusion (particle diffusion)	**K_P**	0.007	0.006
	R^2	**0.9472**	**0.9563**
Intraparticle Diffusion (Penetrant transport)	**a**	0.0853	0.105
	k_{id}	1.643	1.5809
	R^2	**0.9973**	**0.9841**

4. Conclusion

A total of seven kinetic and diffusion models were applied to the adsorption data to determine the controlling kinetics and the rate limiting mechanism. The correlation coefficients(R^2 = 0.9985) of the plots of equations applied showed that the pseudo-second order and the Elovich models were the most fitting for the description of Fe^{3+} and Cd^{2+} ions transport from the bulk solution onto the surface of the adsorbents respectively . These models were therefore, the controlling kinetics of the sorption. The intraparticle diffusion (percent adsorbed) plot with the highest correlation coefficient (R^2 = 0.9985) confirmed that the rate limiting diffusion process was penetrant transport or pore diffusion.

References

[1] **Abasi, C.Y., Abia, A.A. and Igwe, J.C.** (2011). Adsorption of Iron (III), Lead (II) and Cadmium (II) Ions by Unmodified Raphia Palm Fruit (*Raphia Hookeri*). *Environmental Research Journal, 5(3): 104 – 113*

[2] **Abasi, C.Y., Abia, A.A. and Igwe, J.C.**(2012). Sorption Kinetics and Intraparticle Diffusivities of Pb (II), Fe (III) and Cd (II) ions on Unmodified Raphia Palm Fruit (*Raphia hookeri*) Endocarp. *Terrestrial and Aquatic Environmental Toxicology, Vol. 6, No. 2, 35 – 39.*

[3] **Abia, A.A., Horsfall, M. Jr. and Didi, O.** (2003). The use of chemically modified and unmodified cassava waste for the removal of Cd, Cu and Zn ions from aqueous solution. *Bioresource Technology* ,**90 (3)**, 345-348

[4] **Abia, A.A. and Igwe, J.C.** (2003). Maize cob and husk as adsorbent for removal of Cd, Pb and Zn ions from waste water. *The Physical Scientist* **2**, 83-94

[5] **Abia, A.A., Orike, B.D. and Edidiong, A.D.** (2007). Adsorption kinetics and modeling of Cu (II) ion Sorption from aqueous solution by mercaptoacetic Acid modified cassava (manihot sculenta cranz) Wastes. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 6(4), 2221 - 2234

[6] **Hanafiah, M.A.K.M., Yahya, M.Z.A., Zakaria, H. and Ibrahaim, S.C.** (2007). Adsorption of Cd(II) ions from aqueous solutions by Lalang (Imperata cylindrica) leaf powder: effect of physicochemical environment. *Journal of Applied Sciences*, 7(4): 489 - 493

[7] **Horsfall, M. Jr. and Spiff, A.I.** (2005a). Sorption of lead, cadmium and zinc on sulphur-containing chemically modified wastes of fluted pumpkin (*Telfairia occidentalis hook f.*). *Chemistry and Biodiversity* **2 (3)**, 373-385

[8] **Chien, S.H. and Clayton, W.R.** (1980). Application of Elovich equation to the kinetics of phosphate release and sorption on soils. *Soil Science Society of American Journal* **44**, 265-268

[9] **Gardea-Torresdey, J.L., Tiemann, K.J., Dokken. K. and Gamez, G.** (1998). Investigation of metal binding in alfalfa biomass through chemical modification of amino and sulfhydryl ligands. In: *Proceedings of 1998 Conference on Hazardous Waste Research, Bridging Gaps in Technology and Culture*, 18th-21st May, Snowbird, Utah, USA, pp 63-75

[10] **Ho, Y.S., Wase, D.A.J. and Forster, C.F.** (1995) Batch nickel removal from aqueous solution by sphagnum moss peat. *Water Research* **29 (5)**, 1327-1332

[11] **Ho, Y.S., McKay, G., Wase, D.A.J. and Forster, C.F.** (2000). Study of the adsorption of divalent metal ions on to peat. *Adsorption Science and Technology* **18 (7)**, 639-650

Licensed Under Creative Commons Attribution CC BY

[12] **Karthikeyan,G., Andal, M.N. and Anbalagan, K.** (2005). Adsorption studies of iron (III) on chitin. *Journal of Chemical Sciences* **117 (6)**, 663-672

[13] **McKay, G.and Poots, V.J.** (1980) Kinetics and diffusion processes in colour removal from effluents using wood as an adsorbent. *Journal of Chemical Technology Biotechnology* **30**, 279-292.

[14] **Qadeer, R. and Akhtar, S.** (2005) Kinetics study of lead ion adsorption on active carbon. *Turk J. Chem.* 29, 95

[15] **Rattan, S.** (2012). A Textbook of Engineering Chemistry, S.K. Kataria & Sons, New Delhi

[16] **Srivastava, S.K., Tyagi, R. and Pant, N.** (1989) Adsorption of heavy metals on carbonaceous materials developed from the waste slurry generated in local fertilizer plants. *Water Resources* **23**, 1161-1165

[17] **Vinod, V.P. and Anirudhan, T.S.** (2002) Sorption of tannic acid on zirconium pillared clay. *Journal of Chemical Technology and Biotechnology* **77 (1)**, 92-101

[18] **Weber, W.J. and Morris, J.C.** (1963). Kinetics of the adsorption on carbon from solution. *Journal of Sanitation and Engineering Division of the American Society of Civil Engineers* **89**, 31-60

[19] **Wankasi, D., Horsfall, M. Jr. and Spiff, A.I.,** (2006). Sorption kinetics of Pb^{2+} and Cu^{2+} ions from aqueous solution by Nipah palm (*Nypa fructicans* Wurmb). *Electronic Journal of Biotechnology* **9 (5)**, 587-592

Licensed Under Creative Commons Attribution CC BY