Proceedings of the 1st Technical Meeting of Muslim Water Researchers Cooperation (MUWAREC)
December 2008 (Malaysia)

EVALUATION OF BANANA PEEL FOR TREATMENT OF ARSENIC CONTAMINATED WATER

[1*]Saima Q. MEMON, [2]Muhammad Iqbal BHANGER and [2]Jamil-Ur-Rahman MEMON
[1]Hi-Tech Central Resources Laboratory
[2]Center of Excellence In Analytical Chemistry
University of Sindh, Jamsoro
Pakistan
Email: msaima77@gmail.com

Abstract

Arsenic is a highly toxic metal and its moblity in surface water and ground water are of great worry. USEPA has reduced the Maximum Admissible Concentration (MAC) to 10 0 g L^{-1} in 2002 due to severe toxic affect on human health. Current remediation technologies are expensive. Thus, use of any treatment technique will put amplified pressure on economy of rural communities. Therefore, in present study banana peel has been evaluated as a cheaper adsorbent. Effect of pH, shaking speed, shaking time, temperature and concentration has been optimized. Removal of arsenic species was found to be independent of pH. Removal process was rapid initially (70-90%) but became slower with passage of time and equilibrium was stablished within 30 min with 95% arsenic removal. Applicabililty of banana peel was tested for the removal of total arsenic from ground water samples obtanied form different regions of Sindh, Pakkistan. Arsenic removal of drinking water samples was found to be 98-100%.

1. Introduction

Pakistan is an arid country with the water availability of 1,000 cubic meters per annum. Main source of dinking water in Pakistan is groundwater. Unfortunately most of the water sources are contaminated and arsenic is one of the most serious contaminant. Both shallow and deep sources have arsenic contamination.

In Punjab over 20% of the population are exposed to arsenic contamination of over 10 0 g L^{-1} in drinking water while nearly 3% of the population are exposed to over 50 0 g L^{-1}. In Sindh, the situation is even worse with 36% and 16% of population exposed to arsenic contaminated water over 10 0 g L^{-1} and 50 0 g L^{-1} respectively [1].

Arsenic occurrence in the environment, its toxicity, health hazards, and the techniques used for speciation analysis has been reviewed by many authors [2-6]. Long term drinking water exposure of arsenic causes skin, kidney and lung cancer, skin thickening (hyperkeratosis) neurological disorders, muscular weakness, loss of

appetite, and nausea [7-9]. A large number of removal methods based on coagulation, ion-exchange, reverse osmosis and flocculation have been developed for Arsenic removal [10-11] however, and these methods are associated with several disadvantages [12-13]. Sorption using plant waste material is impending alternative to chemical methods for the removal of metal ions from water systems [14-15]. Number of the low cost materials reported in literature [16-17] is not easily available in arsenic contaminated areas of Pakistan so that their use would add the additional cost in removal process. This study presents possible use of banana peel, a commonly avalible waste material for economical removal of arsenic.

2. Results and Discussions

2.1 Adsorption as a function of pH

Percent adsorption as a function of pH on the adsorption of both trivalent and pentavalent arsenic is presented in Figure 1. Adsorption of both species is independent of pH which makes banana peel a practical adsorbent for arsenic removal.

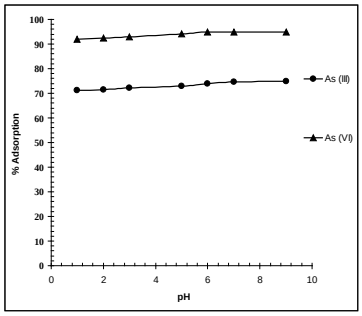

Figure 1: Adsorption of Arsenic species on banana peel as a function of pH

2.2 Contact time optimization and kinetic modeling

Uptake was also optimized with respect to time in order to know the kinetc of the adsorption process, time dependent results of adsorption are given in Fig 2. Figure shows that the uptake rate was initially rapid, with 70% and 90% with in few minutes but became slower as the time passed on and equilibrium established within 30 min and 75% and 95% sorption was recorded for As(III) and As(V) respectively. There was no significant increase in the percent sorption after 30 min. Therefore, 30 min agitation time was selected for further experiments.

Kinetics of adsorption is an important characteristic in defining the efficiency of adsorption. Various kinetic models have been proposed by different researchers, where the adsorption has been investigated as first order [18-19], Pseudo-first-order

[20-21] and Pseudo-second-order [22]. The Lagergren's rate equation [23] is used most widely [18-19, 24] for the sorption of a solute from a liquid solution. The linear form equation is given by

$$\log(q_e - q_t) = \log q_e - \frac{k}{2.303}t$$

where q_e and q_t are the amount of arsenic adsorbed at equilibrium and at time t, respectively, and k is the Pseudo-first-order rate constant. The values of $\log(q_e-q_t)$ were plotted against time t. The plots were linear with correlation coefficients (R^2 = 0.999) which indicates that Lagrgren's model is fitting to the arsenic adsorption on banana peel and that the process is pseudo-first-order.

Slope of the plot gave the value of rate constant k = 0.106 ± 0.005 min^{-1} and 0.214 ± 0.008 min^{-1} for both As(III) and As(V) ions.

2.3 Concentration effect at constant temperature

Adsorption effectiveness of banana peel for arsenic adsorption was determined by plotting different adsorption isotherms. The equilibrium adsorption experiments were performed out at 25±°C in the range of 0.5-1000 mg L^{-1} using 100 mg adsorbent. Adsorption data was examined by Langmuir, and D-R isotherm using following equations

$$\frac{C_e}{C_{ads}} = \frac{1}{Q_b} + \frac{C_e}{Q}, \text{ and}$$

$$\ln C_{ads} = \ln X_m - \beta\varepsilon^2 \text{ Where, } \varepsilon = RT\ln\left(1 + \frac{1}{C_e}\right)$$

where C_{ads} is arsenic adsorbed on one gram of banana peel, C_e is arsenic in aqueous phase, Q, b are Langmuir constants and X_m, and β are D-R isotherm constants. Q, b, X_m, and β were calculated from linear plots of Langmuir and D-R equations. All the results are shown in Table 1.

The sorption capacity values are different for both adsorption isotherms. This difference may be understood by considering the theoretical assumptions of these adsorption models. The numerical values of sorption energy (E) calculated from D-R isotherm (7.58 ± 0.12 and 7.94 ± 0.06 kJ mol^{-1}) for As(III) and As(V) are below 9 kJ mol^{-1} expected for physic-sorption [25-26]. Hence, it is very likely that the type of adsorption is physical in nature in both cases.

Table 1: Sorption parameters of As(III) and As(V) ions onto banana peel.

Isotherm parameter		As(III)	As(V)
Langmuir isotherm	Q (mmol g^{-1})	74 ± 11	107 ± 4
	b (L mol^{-1})	75.4 ± 11.3	293.2 ± 11
	Regression coefficient (R^2)	0.96	0.99
	R_L (dimensionless factor)	0.99-0.6	0.99-0.28
D-R isotherm	X_m (mmol g^{-1})	54.1 ± 8.9	168 ± 16
	E (kJ mol^{-1})	7.58 ± 0.12	7.94 ± 0.06
	Regression coefficient (R^2)	0.99	0.99

2.4 Applications

Applicability of banana peel was tested by removing arsenic from contaminated water of different areas of Sindh. 100 mL of water samples were filtered and mixed with the banana peel, samples were shaken for 30 minutes. Arsenic contents of solution were determined before and after adsorption. Percentage removal was determined from difference. Table 2 shows the removal results.

Table 2: Determination of total arsenic from ground water samples

Sample location	% Removal
Sonara Muhallah Hala (new)	100
Pir Pinealdho Coloni Hala (new)	99
Talib-ul-Mola Coloni Hala (new)	100
Nawabshah	100
Latifabad No. 4 Hyderabad	98
Tap water, Sindh University, Jamshoro	100
Matiari (city)	97
Khairpur (city)	99

3. Conclusions

The present study has explored the potential of banana peel for the removal of total arsenic from ground water samples. The energy value obtained from D-R isotherms indicated that the sorption was physical in nature for both arsenic species. Study shows that banana peels has potential to remove the total arsenic from ground water samples.

4. References

[1] T. Ahmed, M. A. Kahlown, A. Tahir and H. Rashid, "*Arsenic an Emerging Issue: Experiences from Pakistan*" 30th WEDC International Conference, Vientiane, Lao PDR, 2004, people-centred approaches to water and environmental sanitation.

[2] I. Bodek, W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Environmental Inorganic Chemistry: Properties, Processes and Estimation Methods, Pergamon Press, USA, 1998.

[3] W.R. Penrose, *Arsenic in the marine and aquatic environments, Analysaism occurrence and significance*, Crit. Rev. Environ. Contr. 4, 1974.

[4] M. Bissen, F.H. Frimmel, *Arsenic- a review. Part I. Occurance, toxicity speciation, mobility*, Acta Hydrochim. Hydrobiol. 31 (2), 2003.

[5] N.E. Korte, Q. Fernando, *A review of As(III) in ground water*, Crit. Rev. Environ. Contr. 2 (1) 1991.

[6] J.O. Nriagu, JM Azcue, in: J.O. Nriagu (Ed.), Arsenic in the Environment. Part 1. Cycling and Characterization, JohnWiley&Sons, Inc., New York, 1990.

[7] C.K. Jain, I. Ali, *Arsenic: occurrence, toxicity and speciation techniques*, Water Res. 34, 2000.

[8] M.D. Kiping, in: J. Lenihan, W.W. Fletcher (Eds.), Arsenic, the Chemical Environment, Environment and Man, vol. 6, Glasgow, 1997.

[9] B.K. Mandal, K.T. Suzuki, *Arsenic round the world: a review, Talanta* 58, 2002.

[10] YK Chang, JE Chang, TT Lin, YM Hsu, *Integrated opper containing waste water treatment using xanthate process*. J. Hazard Mater, 94, 2002.

[11] Steven, PK Stenberg, WR Dorn, *Cadmium removal sing cladophora in batch, semi-batch and flow reactors*. Bioresour Technol, 81, 2002.

[12] T Okuda, AU Baes, W Nishijima, Okada, *Coagulation mechanism of salt solution-extracted active component in Moringa oleifera seeds*, Wat Res 35, 2002.

[13] KS Narasiah, A. Vogel, NN Kramadhati, *Coagulation of turbid waters using Moringa oleifera seeds from two distinct sources*. Water Supply 2, 2002.

[14] N Meunier, J Laroulandie, JF Blais, RD Tyagi, *Cocoa shells for heavy metal removal from acidic solutions*. Bioresour Technol 90, 2003.

[15] F Pagnanelli, M Sara, F Veglio, T Luigi, *Heavy metal removal by olive pomace: biosorbent characterization and equilibrium modeling*. Chem Eng Sci 58, 2003.

[16] M.S. Rahaman, A. Basu, M.R. Islam, *The removal of As(III) and As(V) from aqueous solutions by waste materials*, Bioresource Technology 99, 2007.

[17] C. Hui Niua, B. Voleskyb, D. Cleimanb, *Biosorption of arsenic (V) with acid-washed crab shells*, Water Res. 41, 2007.

[18] K. K. Panday, G. Prasad, V. N. Singh, *Copper (II) removal from aqueous solutions by fly ash,* Water Res*. 19, 1985.*

[19] E. Haribabu. Y. D. Upathya, S. N. Upathya, *Removal of phenols from effluents by fly ash,* Int. J. Environ. Stud. 43, 1993.

[20] E. Tutem, R. Apak, C.F. Unal, *Adsorptive removal of chlophenols from water by bituminous shale*, Water Res. 32, 1998.

[21] Y. S. Ho, G.McKay, *The sorption of lead(II) ions on peat*, Water Res. 33, 1999.

[22] Y. S. Ho, J. C. Ng, G. McKay, *Removal of lead (II) from effluents by sorption on peat using second order kinetics*, Sep. Sci. Technol. 36, 2001.

[23] S. Lagergren, about *the theory of so-called a dsorption of soluble substances*, K. Svensk Vetenskapsa Handl. 24 1898.

[24] K. periasamy, C. Namasivayam, *Process sevelopment for removal and recovery of cadmium from waste water by a lowcost adsorbent: adsorption rates and equilibrium studies*, Indus. Eng.Chem.Res. 33, 1984.

[25] M.M. Saeed, *Adsorption profile and thermodynamic parameters of the preconcentration of Eu(III) on 2-thenoyltrifluoroacetone loaded polyurethane (PUR) foam* J. Radioanal. Nucl. Chem*.* 256, 2003.

[26] Helfferich, Ion-Exchange, McGraw Hill, New York, 1962.