

Conventional Technology for Removal of Carbofuran from Aqueous Solution

Roli Saini¹ and Pradeep Kumar²

¹Department of Chemical Engineering and Technology, IIT (BHU), Varanasi-221005
E-mail: ¹roli.6102@gmail.com

Abstract—Conventional technology, adsorption was used for removal of carbofuran from aqueous solution. The adsorption of 2, 3-dihydro-2, 2-dimethylbenzofuran-7-yl methyl-carbamate (carbofuran) on bagasse fly ash (BFA) was studied in batch process. The effects of different parameters such as contact time, pH, temperature, adsorbent dose and initial carbofuran concentration on the adsorption processes were studied. BFA have highest BET surface area. Results showed that equilibrium data well fitted with the Freundlich model. The optimum pH for carbofuran removal was found to be 4. Two kinetic models: the pseudo-first-order and pseudo-second-order was used to analyze the adsorption kinetic data. The adsorption kinetics was better represented by the pseudo-second-order model.

Keywords: Carbofuran, adsorption, bagasse fly ash, kinetics.

1. INTRODUCTION

A pesticide consists of an active ingredient coupled with inert ingredients. Raw materials used in the production of pesticides might include a large number of organic and/or inorganic compounds. The total number of pesticides registered by Central Insecticides Board and Registration Committee (CIBRC) including endosulfan is 234. The use of endosulfan was banned in May 2011 in India. Organ chlorine compounds are highly toxic in nature and the rate of degradation is slow of these compounds. As 30% of the crop was lost due to different pests, insect, mites etc. so the use of pesticides has become inescapable.

Carbofuran is persistent carbamate insecticide from other carbamate or organophosphate insecticides (Salman et al., 2010). The mode of action of carbamate insecticides is mostly similar to organophosphate insecticides. Degradation of carbofuran in soil takes place by hydrolysis, microbial action and, to a lesser extent, photodecomposition. The persistence of carbofuran in environment is dependent upon pH, soil type, temperature, moisture content and the microbial population. The maximum concentration of carbofuran reported by the World Health Organization (WHO) in 3 µg/L in potable water (Salman et al., 2011).

Based on the literature review the objective of this work is removal of carbofuran from aqueous solution using BFA as alternative low cost adsorbents.

2. CHEMICALS AND METHODS

2.1 Chemicals

Technical grade Carbofuran (C₁₂H₁₅NO₃) of 98% purity provided by Sigma–Aldrich. BFA was obtained from a local sugar mill. Distilled water was used to prepare all the solutions. All reagents used in the present study were of analytical grade. Chemical HCl and NaOH were used for pH adjustment.

2.2. Sorbent preparation

BFA was washed with hot water. The washed and dried material was sieved to different mesh sizes from 500-300 µm in electrical sieve shaker. The sieved material was rewashed with deionized water to remove the fine particles and dried in an oven at 100°C for 5 h.

2.3. Characterization of sorbent

Scanning Electron Microscope (SEM, Quanta 200 F, Netherland) was used to examined the surface morphology of BFA. Surface area of the adsorbents can be determined by Brunauer – Emmett – Teller (BET) method. FTIR (Thermo model AVATR 370, Australia) spectrophotometer determines the presence of functional groups in all the adsorbents at room temperature. The concentration of carbofuran in the solution was determined using a HPLC at a corresponding wavelength 280 nm.

2.4 Experimental approach

The removal of carbofuran was conducted at 30°C with batch process. The 50 mg/L concentration of 100 ml carbofuran solution was taken in a 250 ml stoppered conical flasks. pH of the solution was maintained at 6 and 2 g of the adsorbent was added in flasks. This mixture was agitated in a water bath at a constant speed of 120 rpm. Samples were taken at appropriate time intervals for analysis. The effect of pH, contact time and

adsorbent dose was studied by varying the parameters. The pH of the solution was adjusted using either HCl for acid or NaOH for base media.

3. RESULTS AND DISCUSSION

3.1. Characterization of activated carbon

Proximate analysis showed presence of moisture, ash and fixed carbon in BFA. BFA have much higher porosity and surface area. The BET surface area of BFA was found to be 163.84m²/g. The BET average pore size was 25.68 for BFA.

3.2. Effect of pH

Effect of pH on removal of carbofuran has been studied in the range of 2-10. The pH was adjusted, using 0.1N HCl and 0.1N NaOH. Experiment was conducted for 60 min with initial carbofuran concentration 50 mg/L, agitation 120 rpm, and adsorbent dose 2 g/L. Fig. 1 showed that maximum removal was obtained at pH 4.

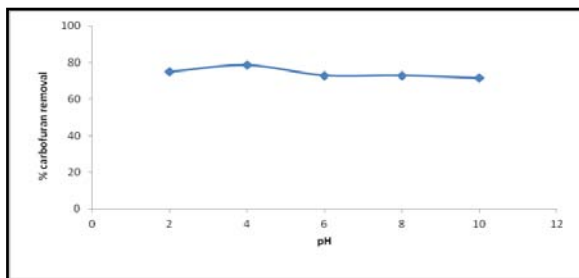


Fig. 1: Effect of pH on % carbofuran removal using BFA (adsorbent dose=2g/l, contact time=180 min, initial concentration C_o=0.5g/l and temp. 30^oC)

3.3. Effect of contact time on pesticide adsorption

The effect of contact time was investigated to maintain the various parameters such as initial concentration 50 mg/L, adsorbent dose 2 g/L, pH 6, agitation speed 120 rpm and temperature 30°C. Experimental results showed that (Fig. 2) removal of carbofuran by BFA required less time to reach in equilibrium because large number of active sites available. Equilibrium time 60 min was observed for the adsorption of carbofuran onto BFA.

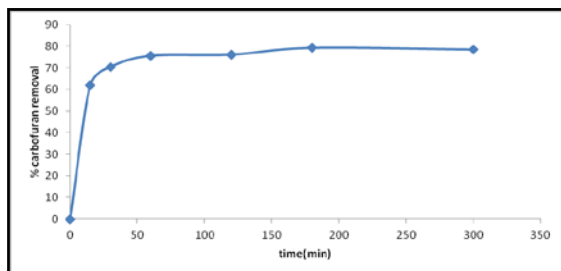


Fig. 2: Effect of contact time on the % carbofuran removal using BFA (C_o= 0.5g/l, adsorbent dosage=2 g/l, pH=6.0 and temperature 30^oC)

3.4. Effect of adsorbent dose on pesticide adsorption

Different adsorbent doses were placed in the 250 ml of conical flask, which contain 100 ml of carbofuran solution. Temperature controlled shaker was used at the agitation speed of 120 rpm and temperature 30°C up to 60 min. From the results it was found that maximum carbofuran removal was obtained at the adsorbent dose of 2 g (Fig. 3).

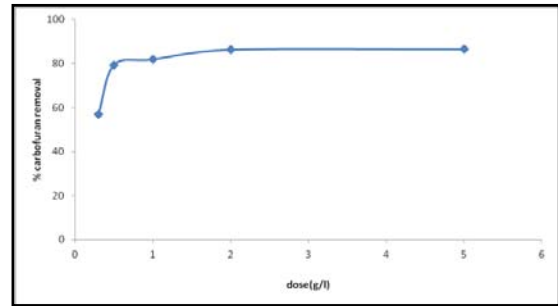


Fig. 3: Effect of adsorbent dose on % carbofuran removal using BFA (pH=4, contact time=180 min, C_o=0.5g/l, temp. =30°C)

3.5. Equilibrium modelling

Two isotherms were experienced to describe their ability, namely the Freundlich isotherm and Tempkin isotherm.

The Freundlich isotherm

(a) The linearised Freundlich isotherms are represented by the following equation.

$$q_e = K_f C_e^{1/n} \tag{1}$$

where C_e is the equilibrium liquid phase concentration (mg/l). K_f is defined as the adsorption or distribution coefficient (l/mg), and (1/n) is the heterogeneity factor. Freundlich model represents better fit data with BFA. Plot shown in fig 3. and fig. 4.

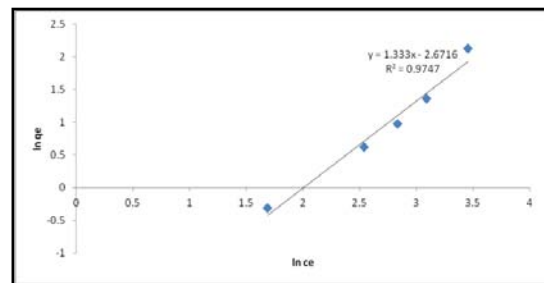


Fig. 4: Freundlich isotherm plot for the removal of carbofuran on BFA (contact time=180 min, adsorbent dose=2 g/l, pH =4)

(b) The Tempkin isotherm

Tempkin isotherm is described as:

$$q_e = \frac{RT}{b \ln(K_T C_e)} \tag{2}$$

This can be linearised as:

$$q_e = B_1 \ln K_T + B_1 \ln C_e \quad (3)$$

Where $B_1 = RT/b$

Tempkin isotherm contains a factor that explicitly takes into account adsorbing species-adsorbent interactions. A plot of q_e vs $\ln C_e$ enables the determination of the isotherms constant B_1 and K_T from the slope and the intercept, respectively.

3.6. Adsorption kinetics

The pseudo-first order model and pseudo-second-order model was used for kinetics modeling of the adsorption of carbofuran on BFA and RHA.

(a) Pseudo first order

Pseudo - first - order model for adsorption analysis is expressed as:

$$\frac{dq_t}{dt} = k_f (q_e - q_t) \quad (4)$$

Where q_t is the amount of adsorbate adsorbed at time t (mg g^{-1}), q_e the adsorption capacity at equilibrium (mg g^{-1}), k_f the pseudo-first-order rate constant (min^{-1}) and t is the contact time (min).

(b) Pseudo second order

The pseudo-second-order model is represented as:

$$\frac{dq_t}{dt} = k_s (q_e - q_t)^2 \quad (5)$$

Where k_s is the pseudo-second-order rate constant (g/mg/min). Integrating above equation and noting that $q_t=0$ at $t=0$, the following equation is obtained:

$$q_t = \frac{t k_s q_e^2}{1 + t k_s q_e} \quad (6)$$

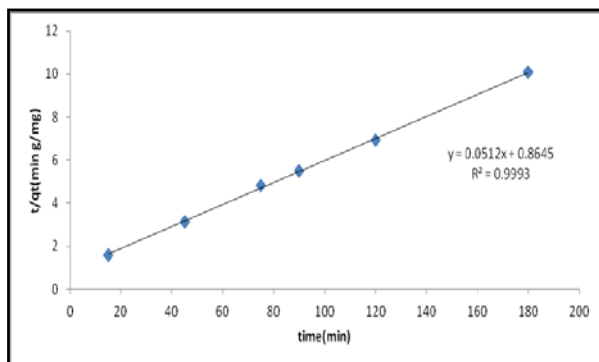


Fig. 5: Pseudo-second-order plot for adsorption of carbofuran on BFA. (pH=4.0, adsorbent dosage=2 g/L, temperature= 30°C, initial carbofuran concentration=50 mg/l)

The initial sorption rate, h (mg/g/min), at $t=0$ is defined as: $h=q_e^2$. It was seen that using BFA pseudo-second-order model better represented the adsorption kinetics.

4. CONCLUSION

Percentage removal of carbofuran is increased with decreasing pH. Maximum carbofuran removal was obtained 40%. The percentage removal of carbofuran was maximum in 60 min. The adsorption of carbofuran on bagasse fly ash and rice husk ash could be described well by Freundlich isotherm equation. Adsorption kinetics can be better represented by a second-order rate expression.

5. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Indian Institute of Technology (Banaras Hindu University), India for financial support of the work undertaken here.

REFERENCES

- [1] Salman J M, Hameed B H, 2010. Adsorption of 2,4-dichlorophenoxyacetic acid and carbofuran pesticides onto granular activated carbon. *Desalination*, 256: 129–135.
- [2] Salman J M, Njoku V O, Hameed B H, 2011. Bentazon and carbofuran adsorption onto date seed activated carbon: kinetics and equilibrium. *Chemical Engineering Journal*, 173: 361– 368.
- [3] Memon G Z, Bhangar M I, Akhtar M, Talpur F N, Memon J R, 2008. Adsorption of methyl parathion pesticide from water using watermelon peels as a low cost adsorbent. *Chemical Engineering Journal*, 138: 616–621.
- [4] Chang K L, Lin J H, Chen S T, 2011. Adsorption studies on the removal of pesticides (carbofuran) using activated carbon from rice straw agricultural waste. World academy of science. *Engineering and Technology*, 52: 348-351.
- [5] Tankiewicz M, Fenik J, Biziuk M, 2010. Determination of organophosphorus and organonitrogen pesticides in water samples. *Trends in Analytical Chemistry*, Vol. 29: No. 9.
- [6] Gupta V K, Ali I, Suhas, Saini V K, 2006. Adsorption of 2,4-D and carbofuran pesticides using fertilizer and steel industry wastes. *Journal of Colloid and Interface Science*, 299: 556–563.
- [7] Salman J M, Njoku V O, Hameed B H, 2011. Bentazon and carbofuran adsorption onto date seed activated carbon: Kinetics and equilibrium. *Chemical Engineering Journal*, 173: 361– 368.
- [8] Salman J M, Hameed B H, 2010. Adsorption of 2,4-dichlorophenoxyacetic acid and carbofuran pesticides onto granular activated carbon. *Desalination*, 256: 129–135.
- [9] Chang K L, Chen C C, Lin J H, Hsien J F, Wang Y, Zhao F, Shih Y H, Xing Z J, Chen S T, 2014. Rice straw-derived activated carbons for the removal of carbofuran from an aqueous solution. *New Carbon Materials*, 29(1): 47–54.