

In vitro adsorption of drugs using modified sugarcane bagasse

Mir Azam Khan^{1*}, Khalid Saeed², Abdullah¹, Waqar Ahmad¹, Fazal Mabood² and Maqsood-ur-Rehman¹

¹Department of Pharmacy, ²Department of Chemistry, University of Malakand, Chakdara, Dir (L), Khyber Pakhtunkhwa, Pakistan

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This study presents activated carbon from sugarcane bagasse (SB) as adsorbent of drugs (Levofloxacin, Hydrochlorothiazide and Paracetamol). Effect of different variables (contact time, initial drug concentration and dose of adsorbent) was studied at acidic pH. SB was characterized by scanning electron microscopy (SEM). Chemical treatments resulted in pore formation within SB sample while surfaces of untreated SB sample were without pores. Maximum adsorption (37%) of drugs from solution was in 1-3 h. Adsorption followed Langmuir isotherm model.

Keywords: Adsorption, Drugs, Morphological study, Sugarcane bagasse (SB)

Introduction

Drug poisoning occurs due to drug inhalation, injection or percutaneous absorption, resulting in toxicity, injury or death. Adsorbent(s) adsorb ingested drug to decrease drug induced toxicity^{1,2}. Activated carbons (AC) from agriculture wastes³ have been used as adsorbents of drugs. High cost of commercial AC limits its use in adsorption for removal of drugs and organic compounds as well^{4,5}. Alkhamis *et al*⁶ used chitosan as an adsorbent for removal of allopurinol and ketotifen. Vergili & Barlas⁷ used organic polymer resin to adsorb pharmaceutical compounds from water. Hamza⁸ used kaolin, aluminum hydroxide and nine other adsorbents to adsorb theophylline. This study used modified sugarcane bagasse (SB) as an adsorbent for removal of drugs [Levofloxacin⁹⁻¹³ (Fig. 1a), Hydrochlorothiazide^{14,15} (Fig. 1b) and Paracetamol¹⁶ (Fig. 1c)].

Experimental Section

Levofloxacin and Hydrochlorothiazide were kindly supplied by Ferozsons Labs Ltd while Paracetamol by Usawa Pharmaceuticals Ltd Nowshera, Khyber Pakhtunkhwa, Pakistan. Raw SB was obtained from Premier Sugar Mills Mardan, Khyber Pakhtunkhwa, Pakistan.

Modification of Sugarcane Bagasse (SB)

Raw SB was grinded, sieved (size 35 μm) and then carbonized in furnace at 300°C for 3 h. After cooling, SB (5 g) was immersed in 1.5 M H_2SO_4 solution according to its liquor ratio (1:5) for 24 h and washed with distilled water in Buckner funnel till turned neutral. Carbonized SB was dried at 100°C, cooled to room temperature (RT) and stored in polybags for further use. For NaOH and urea treatments, grinded SB was sieved (size 35 μm), followed by carbonization in furnace at 300°C for 3 h and immersed in a solution of 1.5M NaOH and 1.0M urea, according to their leaker ratio (1:5 & 1:10 respectively), at RT for 7 days. Treated SB was washed with distilled water in Buckner funnel to remove unreacted NaOH and urea, followed by drying at 100°C, and then cooled to RT and stored in polybags for further work.

Adsorption Kinetic and Equilibrium Isotherm onto adsorbent Samples

Adsorbent (0.1 g) and drug solution (8 ppm) were stirred at 37°C for different time intervals separately and adsorption equilibrium time was determined. Equilibrium isotherm was also studied as a function of drugs concentration at equilibrium time. Concentration of drugs in solution was determined by UV/visible spectrophotometer. Adsorbed amount of drugs was calculated as $q = (C_0 - C_f)V / M$, where q is amount adsorbed (mg/g), C_0 is initial and C_f final concentration (mg/l), V is volume of solution (l) and M is amount of adsorbent (g) used^{17,18}.

*Author for correspondence
E-mail: mirazam786@yahoo.com

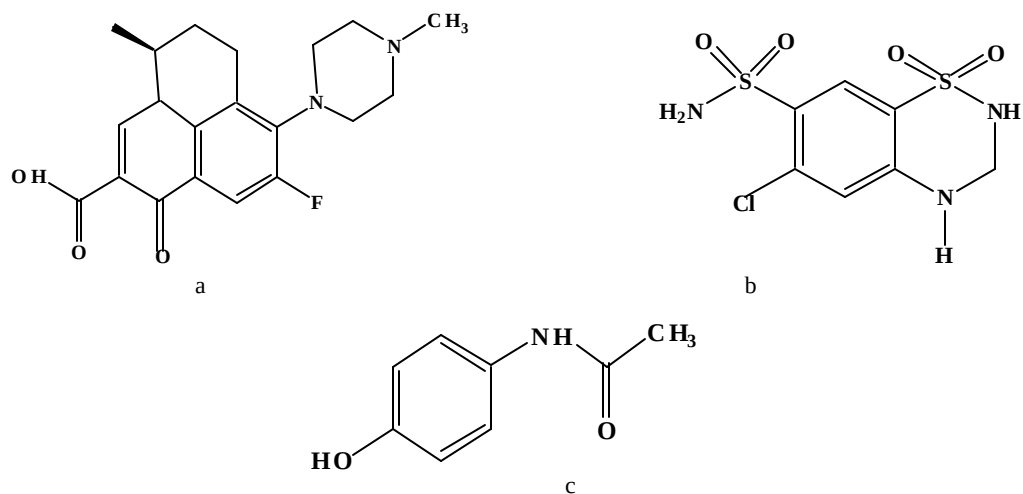


Fig. 1—Structure of drugs: a) Levofloxacin; b) Hydrochlorothiazide; and c) Paracetamol

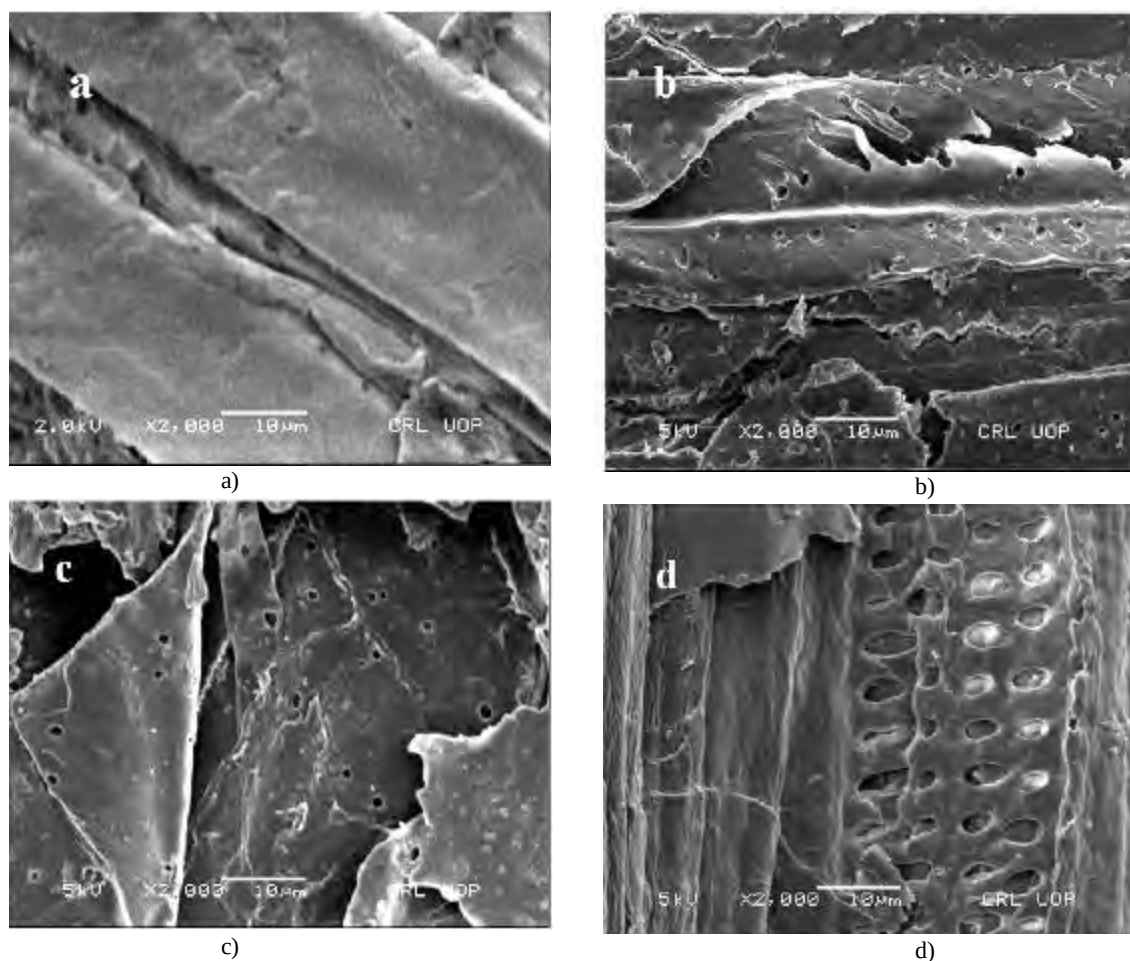


Fig. 2—SEM images of sugarcane bagasse (SB): a) untreated; b) H_2SO_4 treated; c) urea treated; and d) NaOH treated

Results and Discussion

Morphological Study

Scanning electron microscopy (SEM) image shows that surface of untreated SB, heated to 300°C for 3 h without any chemical treatment, is smooth and without

significant pores (Fig. 2a). H_2SO_4 (Fig. 2b) and urea (Fig. 2c) treatment resulted in small sized pores ($< 3 \mu m$), while NaOH (Fig. 2d) treatment resulted in large sized pores ($3-7 \mu m$) in SB sample.

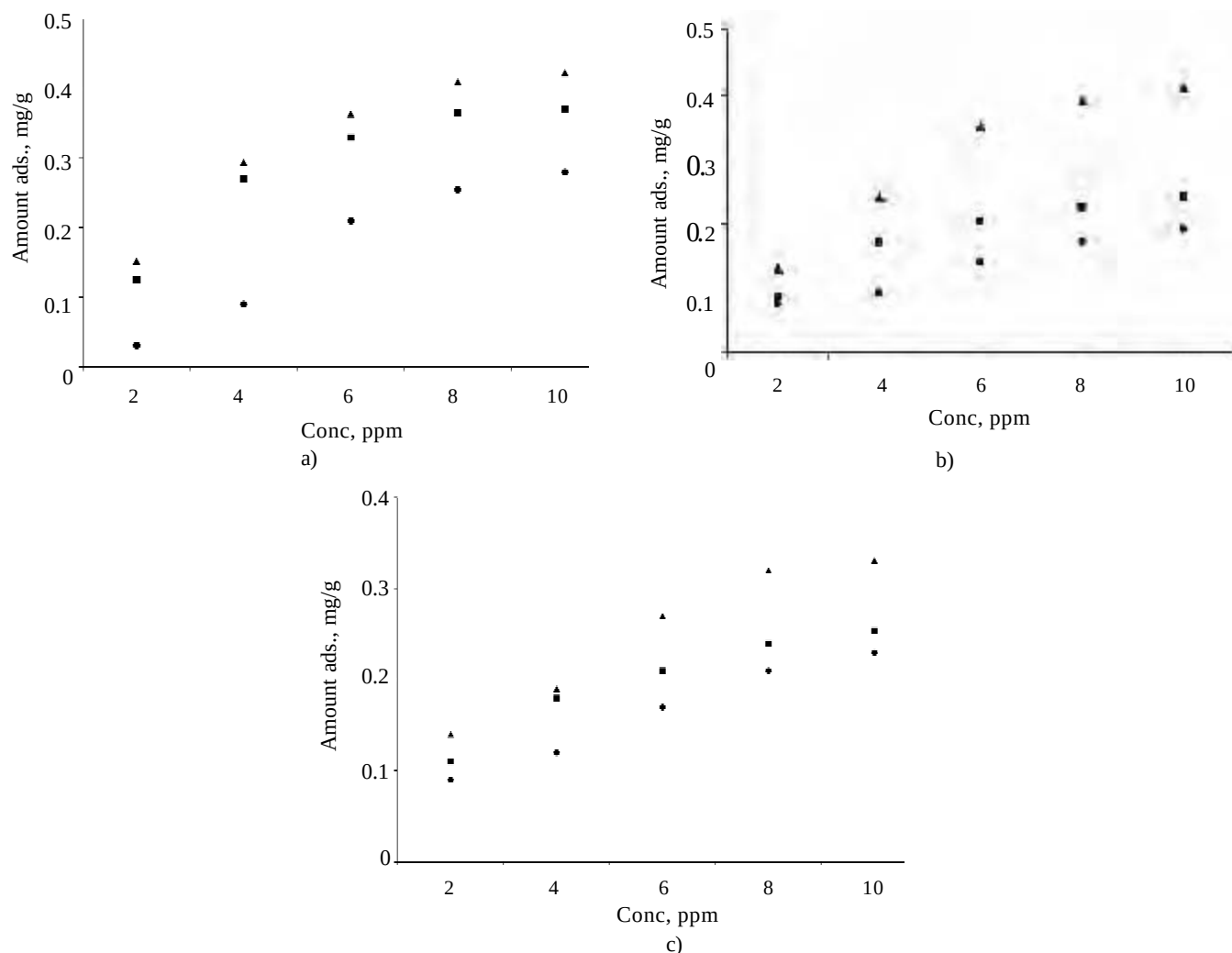


Fig. 3—Effect of concentration of adsorption on sugarcane bagasse (SB) treated with H_2SO_4 (■), NaOH (▲) and urea (●) of drug: a) Levofloxacin; b) Hydrochlorothiazide; and c) Paracetamol

Effect of Concentration

Based on maximum adsorption capacity, NaOH treated SB (0.1 g) was mixed with 15 ml of different concentration of drug solutions (2, 4, 6, 8, and 10 ppm) to determine optimum concentration for maximum adsorption. For Levofloxacin, adsorption was 0.152 mg/g at 2 ppm, which increased up to 0.42 mg/g at 10 ppm. In case of Paracetamol, amount adsorbed at 2 ppm was 0.14 mg/g, which enhanced up to 0.33 mg/g for a solution of 10 ppm concentration. For Hydrochlorothiazide, amount adsorbed was 0.13 mg/g at 2 ppm and 0.41 mg/g at 10 ppm respectively. Adsorption was proportional to increases in concentration up to 8 ppm, beyond which there was no significant increase in adsorption (Fig. 3). Therefore, optimum concentration of drug solutions was found to be 8 ppm for maximum adsorption.

Effect of Adsorbent Dose

Different quantities of NaOH treated SB (0.02, 0.04, 0.06, 0.08 and 0.1 g) were used to investigate adsorption of drugs (Levofloxacin, Hydrochlorothiazide and Paracetamol) from 8 ppm solution (optimum conc. for adsorption) of respective drugs. Adsorption pattern of adsorbent was proportional to the quantity of adsorbent used. Optimum adsorbent (0.1 g) adsorbed maximum drugs as follows (Fig. 4): Levofloxacin, 0.41; Paracetamol, 0.32; and Hydrochlorothiazide, 0.39 mg. There was a linear response between the amount of SB and drugs adsorbed, indicating that adsorption capacity increases with increase in amount of adsorbent.

Adsorption Kinetics

Effect of time (0-3 h) was studied on adsorption of drugs at 37°C to determine the time to attain equilibrium

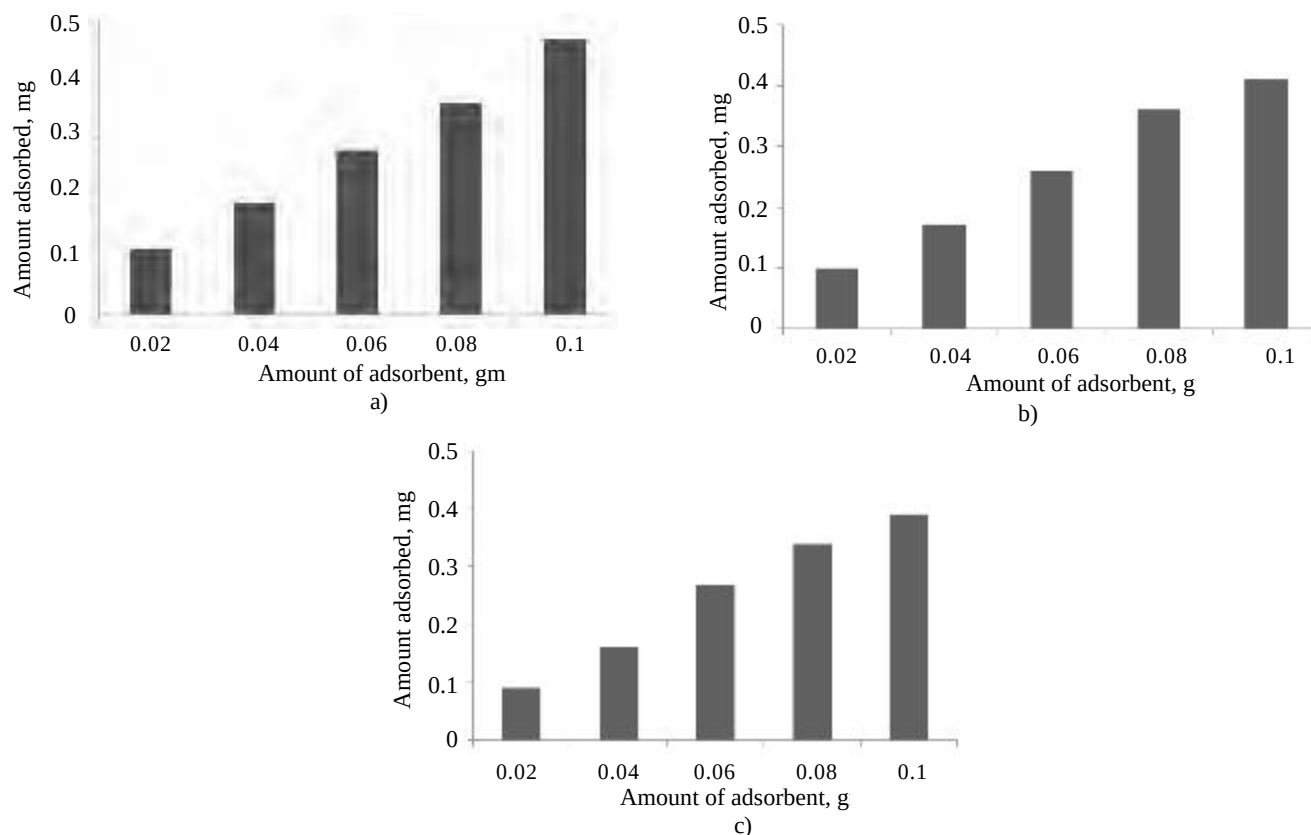


Fig. 4—Effect of adsorbent dose on adsorption of sugarcane bagasse (SB) treated with NaOH of drug: a) Levofloxacin; b) Hydrochlorothiazide; and c) Paracetamol

for each drug. Levofloxacin attained equilibrium within 90 min (Fig. 5a), while Hydrochlorothiazide at 120 min (Fig. 5b) and Paracetamol at 180 min (Fig. 5c). NaOH treated SB removed high quantity of drugs (33-37 wt%) from acidic solution within 1-3 h, may be due to formation of large sized pores (Fig. 2d). Urea treated SB adsorbed least amount of drugs (21-29 wt%) from acidic solution. Thus adsorption of all drugs increased with time duration, due to availability of large number of active sites for adsorption of adsorbate molecules. After optimum duration, adsorption of all drugs decreased, might be due to remaining vacant active sites of adsorbents were difficult to be occupied by adsorbate molecules due to repulsive forces^{4,18}.

Adsorption Isotherm

Adsorption isotherms studies were carried out to determine the condition for adsorption of maximum concentration of drugs from acidic solution onto various treated SB samples. Equilibrium adsorption concentration of drugs [Levofloxacin at 90 min (Fig. 6a), Hydrochlorothiazide at 120 min (Fig. 6b), and

paracetamol at 180 min (Fig. 6c)], indicated that initially uptake of all drugs increased with increase in concentrations and then almost constant after certain concentration. Initial increase in uptake of drugs with increase of its concentration was due to accessibility of numerous active sites on treated SB samples and then adsorption equilibrium was accomplished to maximum due to surface saturation of adsorbent¹⁸.

Langmuir Isotherm

Equilibrium adsorption data of drug samples were fitted to Langmuir equation, which suggests that adsorption occurs at specific homogeneous sites (mono layer adsorption) within adsorbent¹⁹. It means that it may adsorb only one molecule of adsorbate and once the saturation was reached, no adsorption of drugs samples took place. In Langmuir equation ($C_e/q_e = 1/K_L q_m + C_e/q_m$), q_e is quantity of drug adsorbed on treated-SB (mg/g), C_e is equilibrium concentration (mg/L), and q_m and K_L are Langmuir constants related to adsorption capacity and binding energy, respectively²⁰. Values of q_m and K_L were calculated from the slope and intercepts of the plot (Fig. 7 a, b and c) and are shown in Table 1.

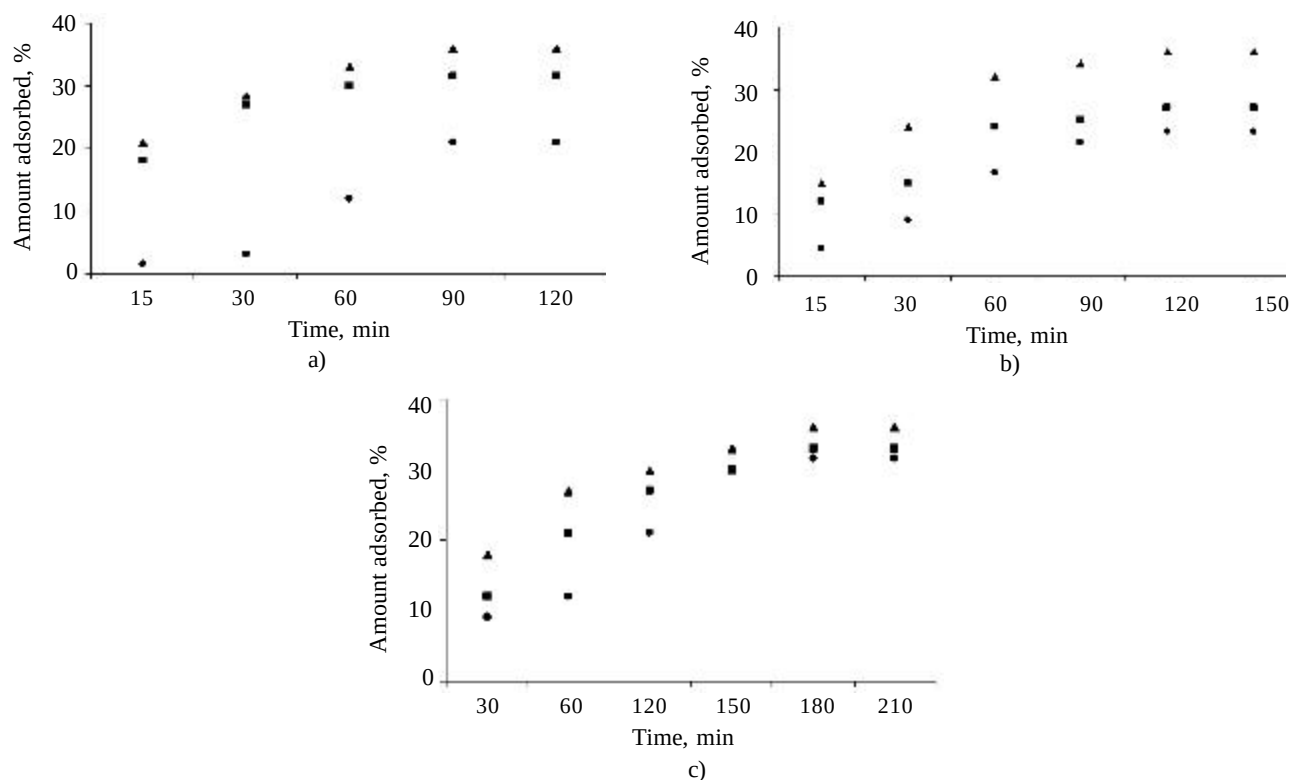


Fig. 5—Effect of contact time on adsorption of sugarcane bagasse (SB) treated with H_2SO_4 (■), NaOH (▲) and urea (●) of drug: a) Levofloxacin; b) Hydrochlorothiazide; and c) Paracetamol

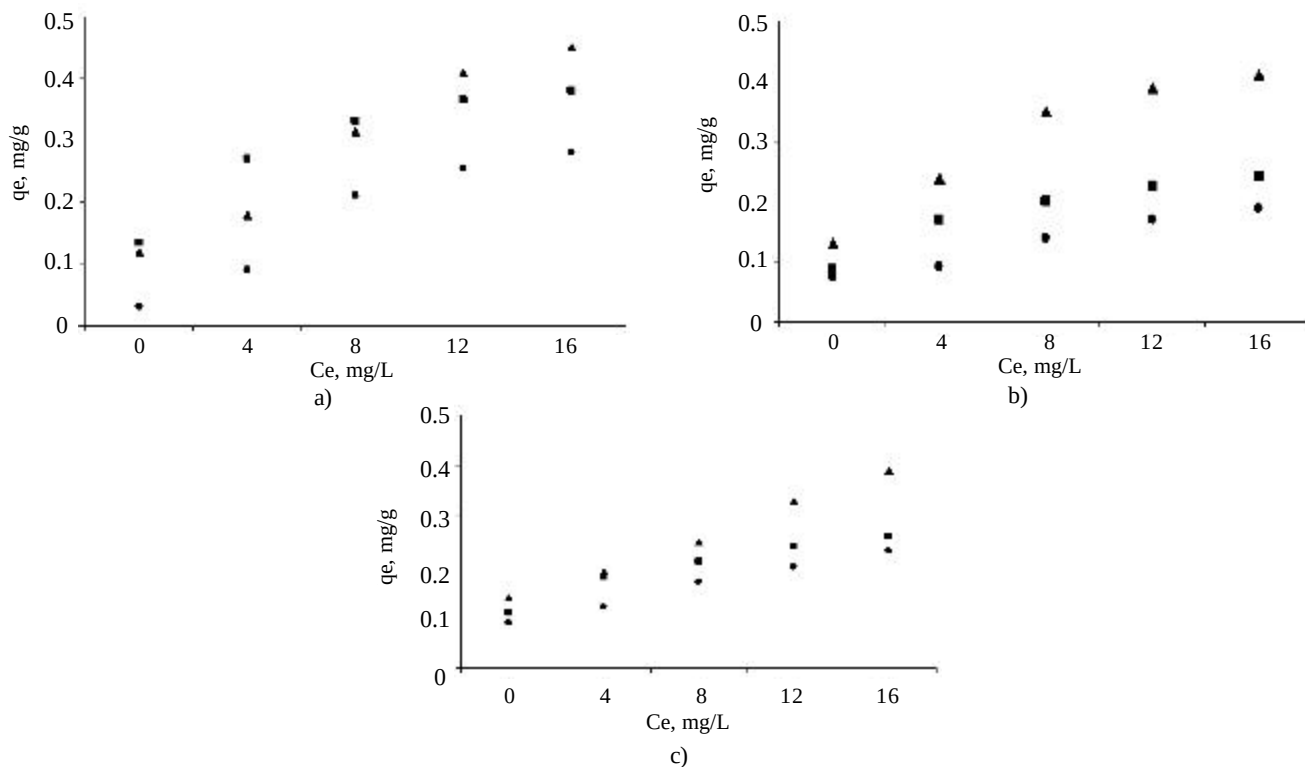


Fig. 6—Adsorption isotherm of sugarcane bagasse (SB) treated with H_2SO_4 (■), NaOH (▲) and urea (●) of drug: a) Levofloxacin; b) Hydrochlorothiazide; and c) Paracetamol

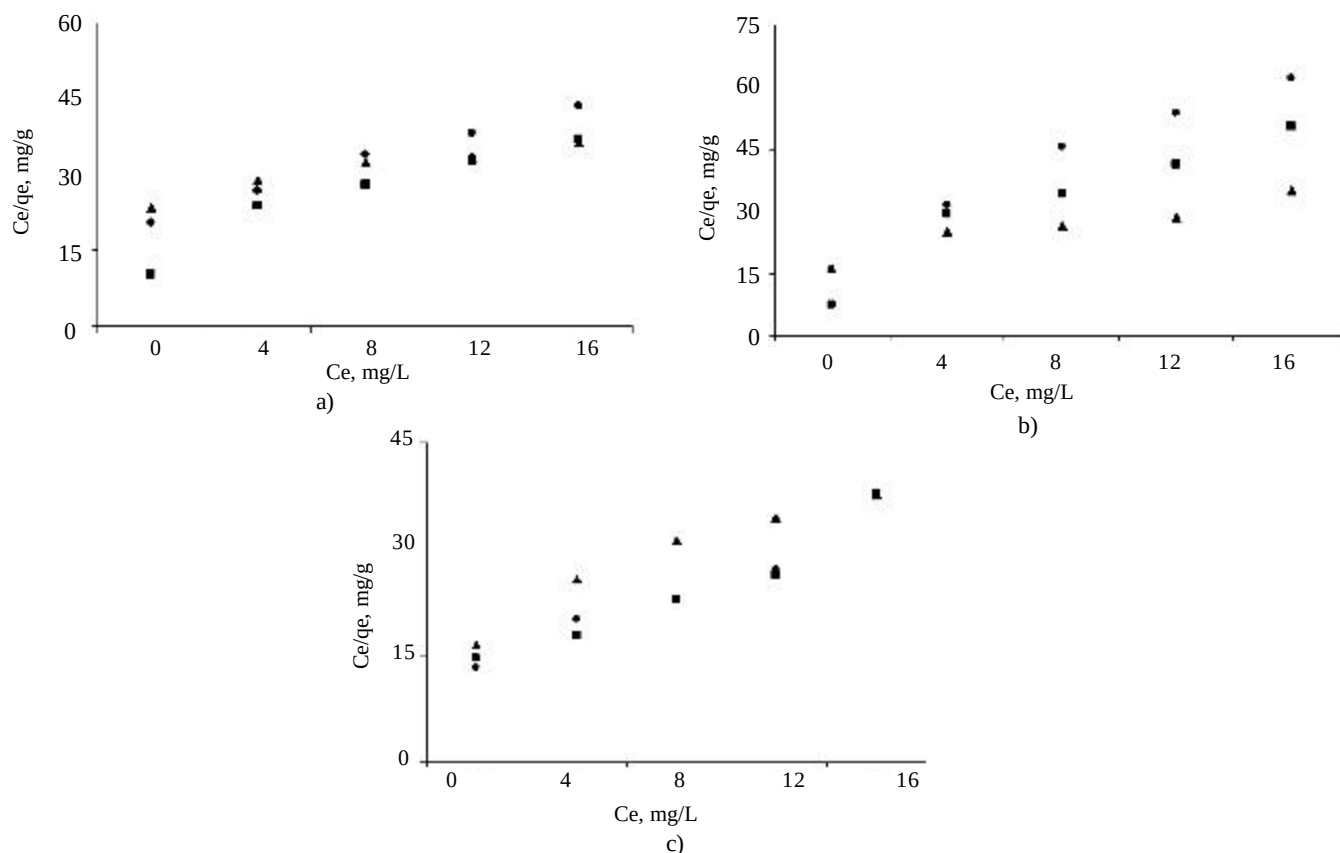


Fig. 7—Langmuir adsorption isotherm of sugarcane bagasse (SB) treated with H_2SO_4 (■), NaOH (▲) and urea (●) of drug: a) Levofloxacin; b) Hydrochlorothiazide; and c) Paracetamol

Table 1—Langmuir constants of drugs on treated sugarcane bagasse (SB)

Sugarcane bagasse (SB) samples	Levofloxacin		Hydrochlorothiazide		Paracetamol	
	q_m	K_L	q_m	K_L	q_m	K_L
H_2SO_4 treated	0.847	22.71	1.396	14.385	2.838	9.238
NaOH treated	2.0465	8.6576	3.655	7.744	1.604	15.914
Urea treated	1.8742	20.488	4.117	15.912	3.096	10.83

Conclusions

Conversion of raw SB into AC is economical and also effective for removal of drugs (Levofloxacin, Hydrochlorothiazide and Paracetamol) from acidic solutions under normal body temperature, which can decrease toxic effects of these drugs in case of poisoning. Chemical treatments change surface morphology of SB samples and produced different sized pores on the surface of adsorbent. Treated SB samples removed around 37% of Levofloxacin (90 min), Hydrochlorothiazide (120 min) and Paracetamol (180 min) from acidic solution. Equilibrium adsorption isotherm obeyed Langmuir equation and the data followed Langmuir isotherm model.

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