SUGARCANE BAGASSE PITH AS A LOW COST ADSORBENT FOR THE REMOVAL OF METHYLENE BLUE FROM WASTE WATER: EXPERIMENTAL AND MODELING STUDY

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Degree of Master of Science in Sustainable Process Development

Department of Chemical and Process Engineering

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Thesis submitted in partial fulfillment of the requirements for the degree

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

Contamination of water streams due to discharge of dye containing wastewater is a worldwide problem. Adsorption is an effective and efficient method for removing dye stuff from waste water. However high cost of commercial adsorbents limit its use in wastewater treatment.

In this study potential of untreated sugarcane bagasse pith as a low cost adsorbent for removal of Methylene Blue (MB); a basic dye, was investigated. Batch experiments were conducted to determine the factors affecting dye removal. Results revealed that the percentage of dye removal depends on adsorbent dosage, initial dye concentration of the solution, solution pH and contact time. Distinctly low MB removal was observed at low solution pH values (<4). At high pH values (4 to 10), high MB removal was obtained and variation of percentage removal with pH was not significant. Equilibrium data fits to Langmuir isotherm and highest dye uptake of 40mg/g was observed. Adsorption rate was very rapid initially and gradually decreased with time.

Fixed bed column experiments were performed to study practical applicability and characteristic '*S*' shape breakthrough curves were obtained. Increase in breakthrough time and bed capacity was observed when the bed height is increased. Fixed bed column data were fitted to Bed Depth Service Time (BDST) model and Yoon Nelson model for different bed heights.

In this work, new mathematical model was developed based on film-pore diffusion in non equilibrium conditions to study the dynamics of the column for methylene blue adsorption. Model consists of a system of partial differential equations (PDEs), accounts for the effects of axial dispersion, film-pore diffusion, and external mass-transfer resistances. External mass transfer coefficient calculated using kinetic data obtained from batch experiments was found to be 0.7096 cm min^{-1} and this valve was used for model calculations. Using the model, effect of bed height and initial concentration on breakthrough curves were predicted. Further, concentration distribution along the radial direction of bagasse particles at different locations of the bed was analyzed. This model was validated using experimental data obtained by fixed bed column experiments.

Key Words :Methylene blue dye, Baggase, Adsorption, Film-pore diffusion,

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LIST OF ABBREVIATIONS

BDST	-	Bed depth services time model
GAC	-	Granular activated carbon
MB	-	Methylene blue
NOMA	-	Norad's programme for master studies
ODE	-	Ordinary differential equation
PDE	-	Partial differential equation
RPM	-	Revolutions per minute
UV	-	Ultra violet

NOMENCLATURE

A	Cross sectional area of the column (cm^2)
A_p	External surface area of the pith particles (cm^2)
b	Langmuir equilibrium constant(L/mg)
C_t	Liquid phase concentration (mg/L)
C_p	Particle phase concentration macro pores (mg/L)
C_{pi}	Particle phase concentration micro pores
C_b	Bulk fluid concentration used in model (mg/L)
C_e	Equilibrium liquid phase concentration (mg/L)
C_0	Initial liquid phase concentration (mg/L)
c_b	Dimensionless bulk fluid concentration used in model
c_p	Dimensionless particle phase concentration macro pores
D_L	Axial dispersion coefficient (cm^2/min)
D_m	Molecular diffusivity (cm^2/min)
D_p	Pore diffusion coefficient (cm^2/min)
D_s	Surface diffusion coefficient (cm^2/min)
d_p	Particle diameter (cm)
d_c	Column diameter (cm)
F	Flow rate (ml)
H_B	Length of the used bed (cm)
H_{UNB}	Length of the unused bed (cm)
H_T	Total length of the bed (cm)
k_f	External mass transfer coefficient (cm^2/min)
K	Dimensionless group constant
K_F	Constant used in Freundlich isotherm ($mg^{0.57}$ $L^{0.43}$/g)
K_B	Constant used in BDST model (L $mg^{-1}min^{-1}$)
k_{YN}	Yoon-Nelson constant (L min^{-1})
K'	Constant used in linear isotherm
L	Length of the column (cm)
n	Constant used in Freundlich isotherm

N_0	Constant used in BDST model (mg L^{-1})
N_{Bi}	Biot number
N_{pe}	Peclet number
q_m	Langmuir constant (mg/g)
q_e	Adsorption capacity at equilibrium (mg/g)
R_p	Radius of the particle (cm)
R	Radial coordinate (m)
r	Radial coordinate (dimensionless)
Re	Reynolds number
Sc	Schmidt number
Sh	Sherwood number
t	Time (min)
t_t	Time equivalent total capacity of the bed (min)
t_u	Time equivalent to usable capacity of the bed (min)
t_b	Breakthrough time of the bed (min)
$t*$	Scaled version of dimensionless time
v_s	Superficial velocity (cm min^{-1})
v	Interstitial velocity (cm min^{-1})
V	Volume of the solution (ml)
W	Mass of bagasse (g)
Z	Axial distance (cm)
z	Axial distance (dimensionless)
ρ_w	Density of solution (g/cm^3)
ρ_p	Bagasse particle Density (kg/m^3)
ρ_s	Bagasse skeletal Density (kg/m^3)
ε_b	Bed porosity
ε_p	Particle porosity
η	Dimensionless group constant
μ_w	Dynamic viscosity of the solution (g cm^{-1} s^{-1})
τ	Constant used in Yoon-Nelson model (min)
$\emptyset$	Conservative form of any fluid property