The Potential of Gundelia Seeds Waste as an Emerging Sustainable Adsorbent for Dye-Polluted Water Treatment

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Supplementary Information

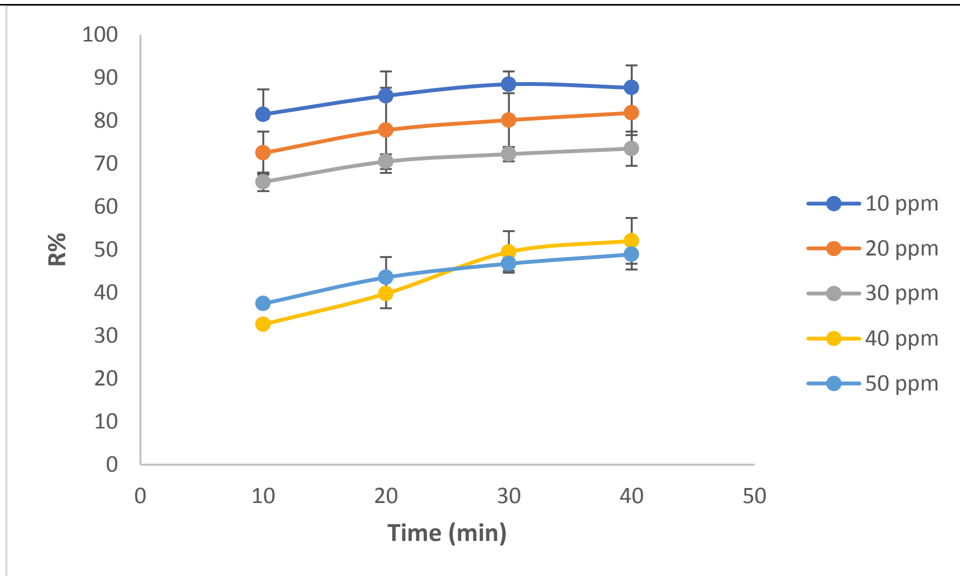
Table S-1. Kinetics models used in this study

Kinetics model	Equation	Constant
Zero Order	$(q_t - q_e) = q_e - K_Z t]$	K_Z is the rate constant of zero-order adsorption (mg/g.min)
Pseudo-First Order	$log(q_e - q_t) = log\, q_e - \frac{K_1}{2.303} t$	K_1 is the rate constant of pseudo-first-order adsorption (per min.)
Pseudo-Second Order	$\frac{t}{q_t} = \frac{1}{K_2 {q_e}^2} + \frac{t}{q_e}$	K_2 is the pseudo-second-order rate constant (per min.)
Elovich	$[q_t = \alpha + \beta\, ln\, t$	α is the initial adsorption rate (mg/g) and β is adsorption constant (mg/g.min)
Intraparticle Diffusion	$q_t = K_p t^{0.5} + C$	K_p and C are intra-particle diffusion rate constant (mg/g. min0.5) and the thickness of the boundary layer (mg/g), respectively

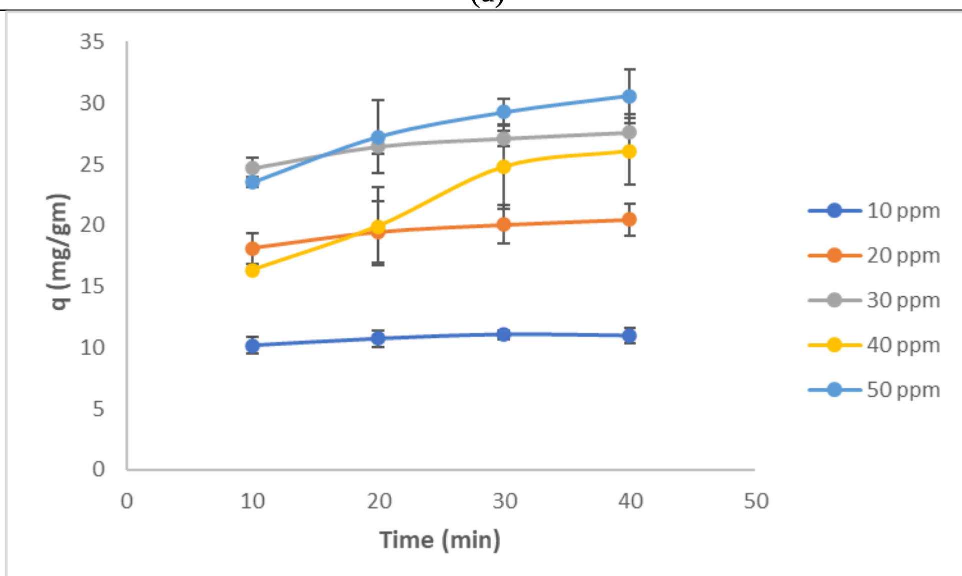
Table S-2. Equations of the adsorption isotherms.

Isotherm	**Equation**	**Constant**
Langmuir	$[\frac{c_e}{q_e} = \frac{1}{K_L q_L} + \frac{c_e}{q_L}]$	K_L: Langmuir constant related to the free energy of adsorption (L/mg)
Freundlich	$[\ln q_e = \ln K_F + \frac{1}{n_f} \ln c_e]$	K_F: is constant indicative of the relative adsorption capacity of adsorbent (mg/g). $\frac{1}{n_f}$: is the constant indicative of the intensity of the adsorption process
Temkin	$[q_e = q_T \ln K_T + q_T \ln c_e]$	$q_T = \frac{RT}{b_T}$: is the Temkin isotherm parameter (mg/g). where T(K^o) is the absolute temperature, R is the universal gas constant, K_T (L/mg) is the equilibrium binding constant, and b_T (J/mol) is related to the heat of adsorption.

S1- Dose of 0.02 g



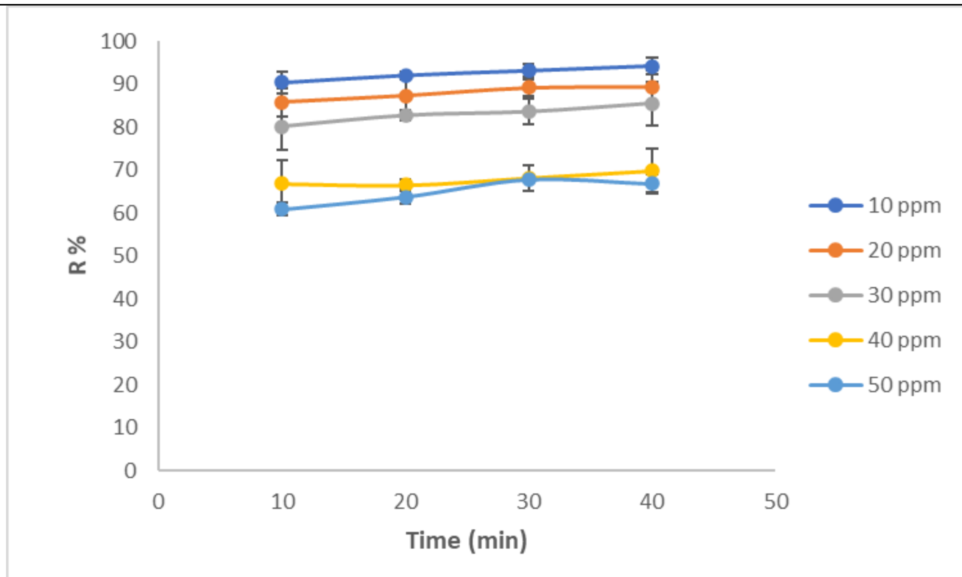
(a)



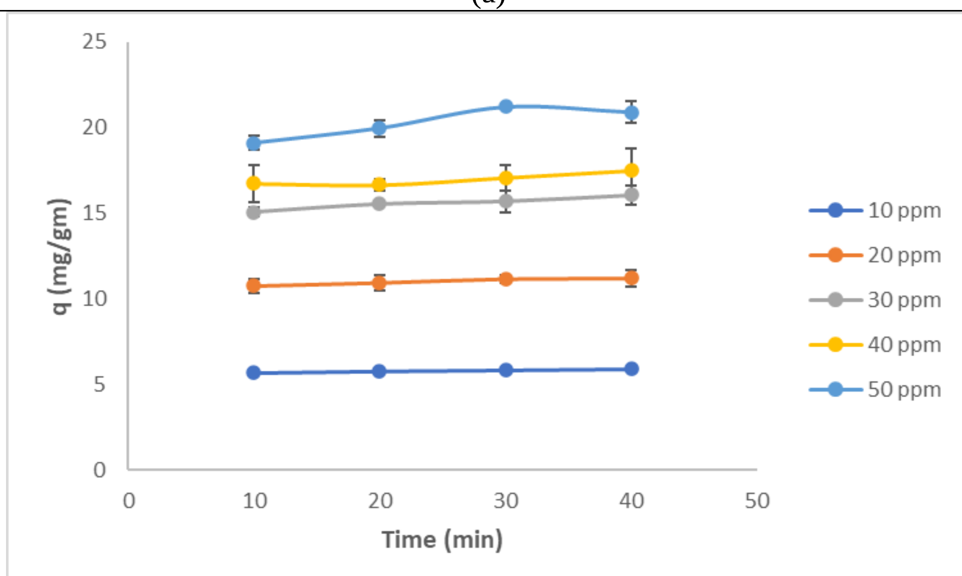
(b)

Figure S1. The effect of time on (a) removal rate and (b) adsorption capacity at different initial dye-solution concentrations using a dose of 0.02 g.

S2- Dose of 0.04 g



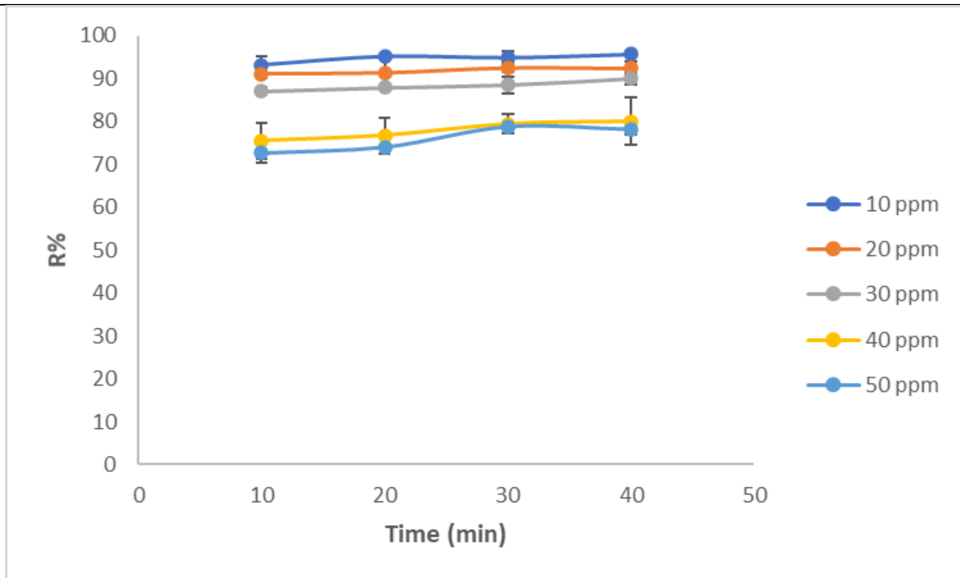
(a)



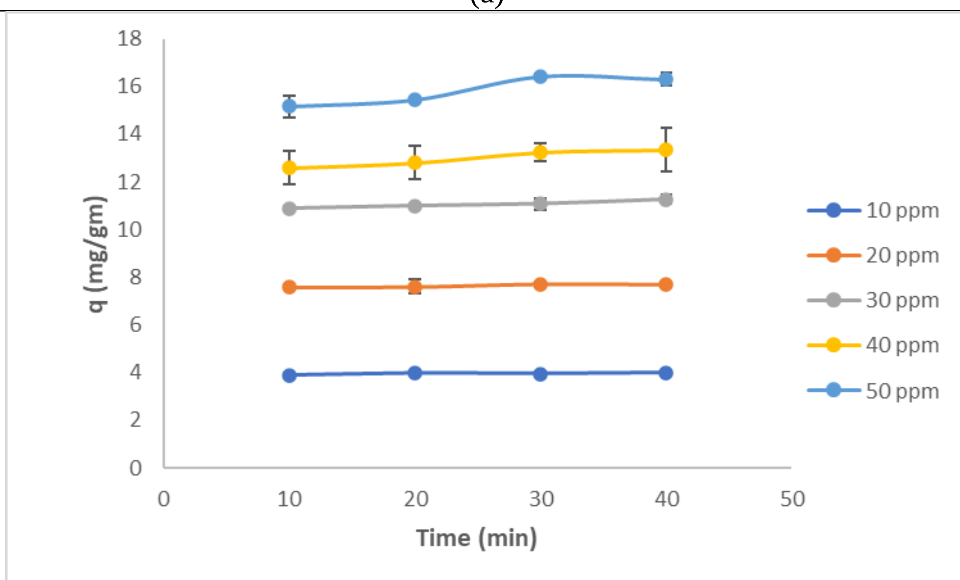
(b)

Figure S2. The effect of time on (a) removal rate and (b) adsorption capacity at different initial dye-solution concentrations using a dose of 0.04 g.

S3- Dose of 0.06 g



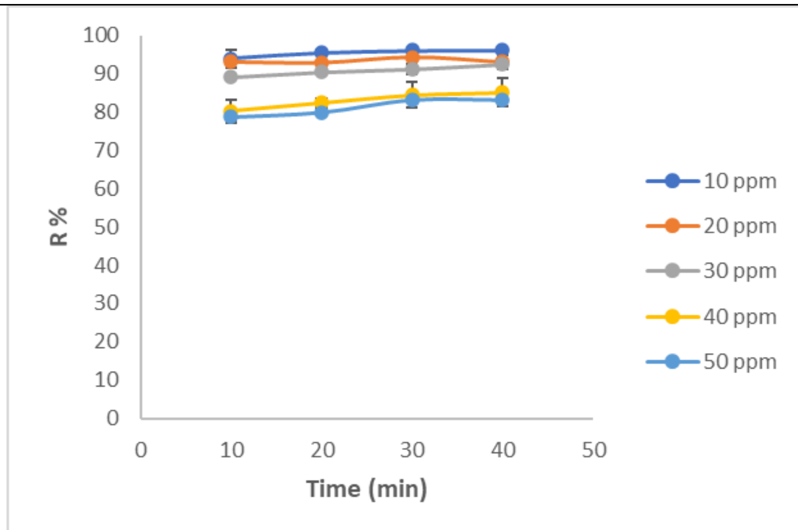
(a)



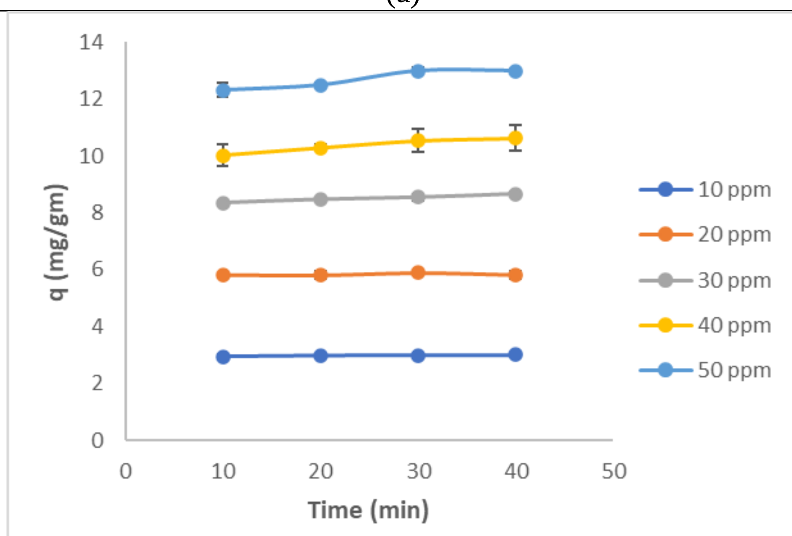
(b)

Figure S3. The effect of time on (a) removal rate and (b) adsorption capacity at different initial dye-solution concentrations using a dose of 0.06 g.

S4- Dose of 0.08 g



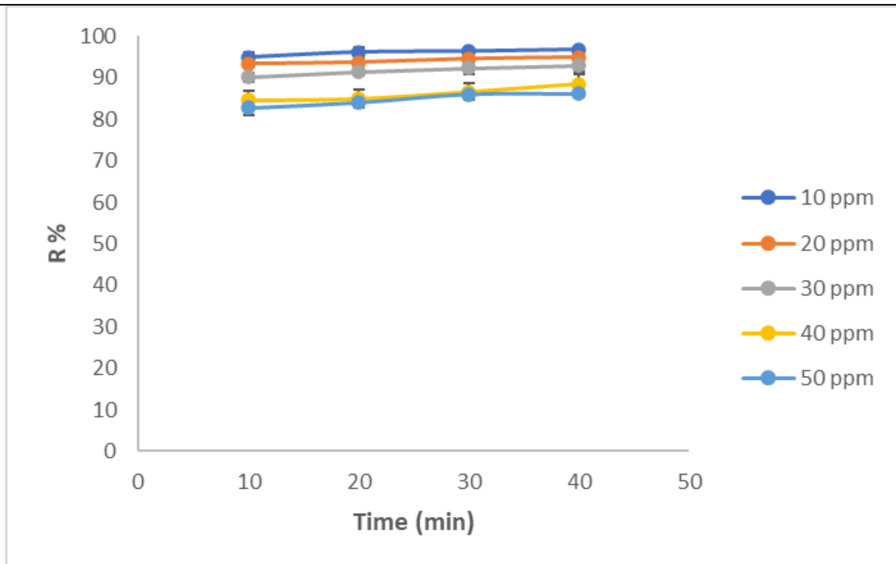
(a)



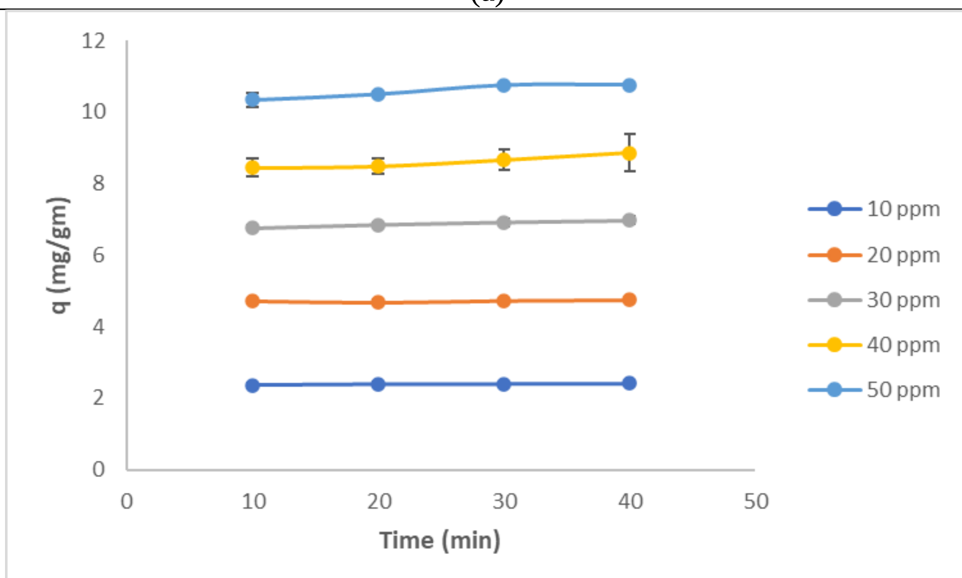
(b)

Figure S4. The effect of time on (a) removal rate and (b) adsorption capacity at different initial dye-solution concentrations using a dose of 0.08 g.

S5- Dose of 0.1 g



(a)



(b)

Figure S5. The effect of time on (a) removal rate and (b) adsorption capacity at different initial dye-solution concentrations using a dose of 0.1 g.