Supporting Information

1. XPS analysis

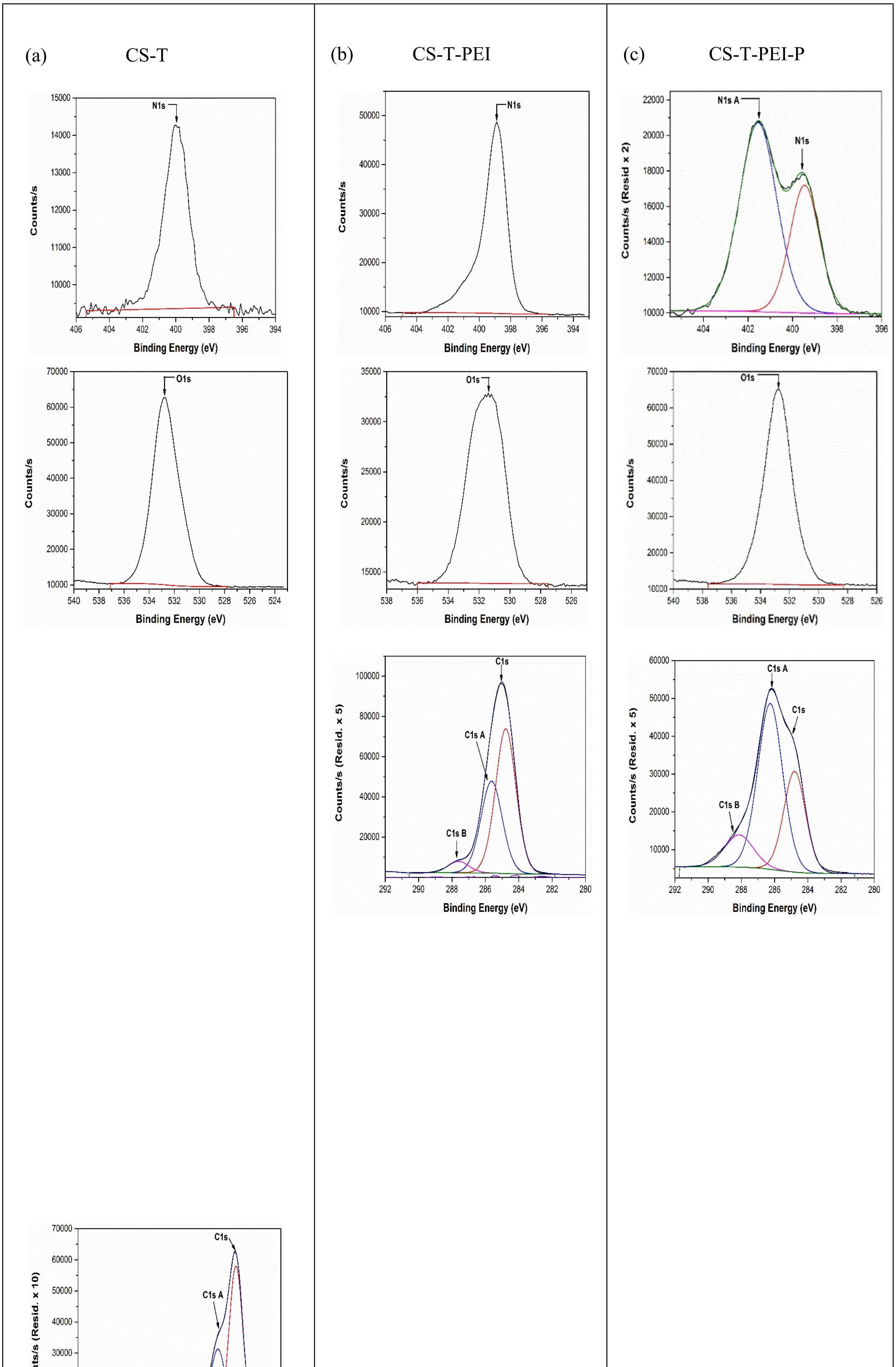

Figure S1. Evolution of the C 1s, O 1s, and N 1s XPS core-level spectra of a) CS-T, b) CS-T-PEI and c) CS-T-PEI-P.

2. Influence of pH on ion adsorption

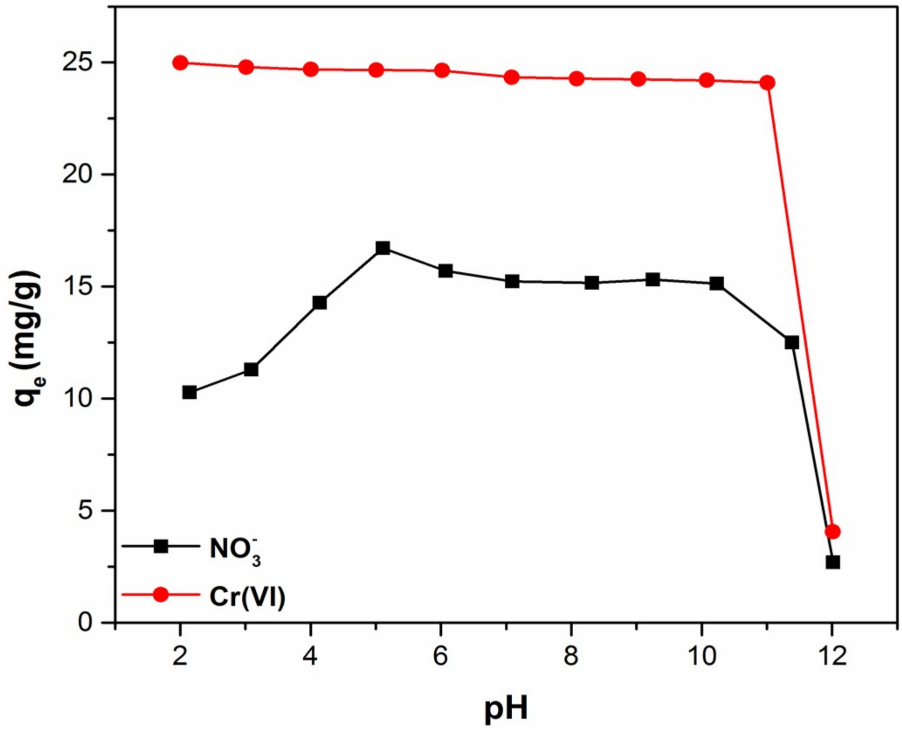

Figure S2: Effect of pH on NO_3^- and Cr(VI) adsorption onto CS-T-PEI-P (Ci = 100 mg/L, V = 50 ml, m_{ads} = 0.2 g, 300 rpm).

3. Parameter effects and surface interactions

Fig. S3 shows that the sorption process was rapid during the initial stage (5 – 60 min) for all the tested concentrations. This was attributed to the high concentration gradient near the surface in the beginning of the adsorption process, which exerted a high driving force and thus favored migration of NO_3^- and Cr(VI) from the solution to the surface of CS-T-PEI-P. Then, the sorption rate was slower until equilibrium. The equilibrium times for NO_3^- and Cr(VI) adsorption were approximately 240 and 420 min, respectively. The quantity adsorbed at equilibrium for initial NO_3^- and Cr(VI) concentrations of 50, 100 and 150 mg/L were 8.76, 17.04 and 22.12 mg/g for nitrate and 12.45, 24.82 and 36.63 mg/g for chromium (VI), respectively. A further increase in contact time showed no increase in pollutant adsorption but it is clear that NO$_3^-$ and Cr(VI) sequestration increased when the concentrations of initial NO$_3^-$ and Cr(VI) increased (**Fig. S3-a**). Thus, the increase of the adsorption capacity of CS-T-PEI-P with the increase of the initial concentration may be explained by the fact that NO$_3^-$ and Cr(VI) diffusion from the solution to the CS-T-PEI-P surface was accelerated by the gradient of pollutant concentration [1-2].

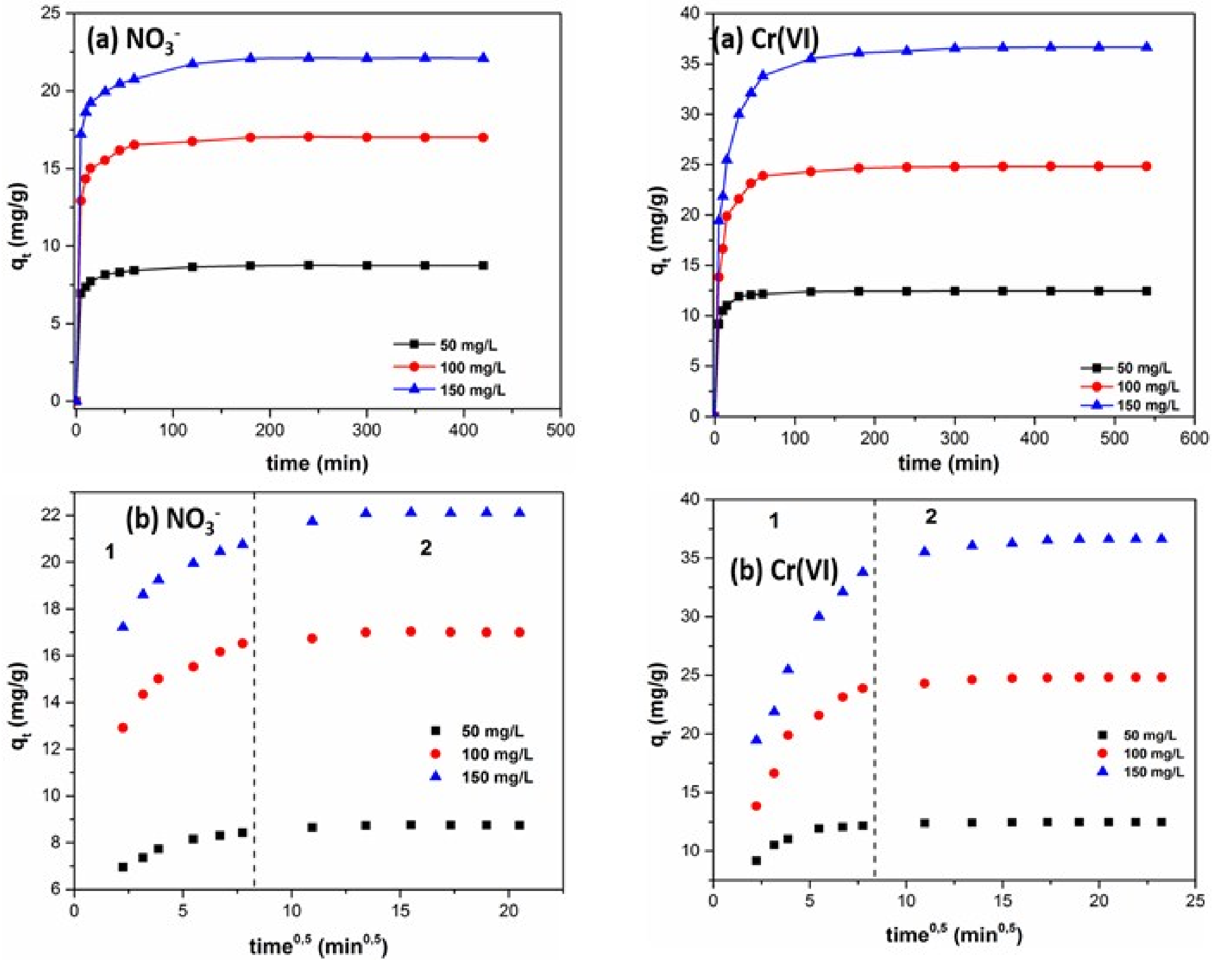

Figure S3: (a) Effect of contact time on the sequestration of NO$_3^-$ and Cr(VI) by CS-T-PEI-P at different initial pollutant concentrations [CS-T-PEI-P dosage: 0.2 g, V = 50 mL, T = 23 ± 2 °C; shaking speed: 300 r.min^{-1} ; initial pH for NO$_3^-$ and Cr(VI)]; (b) intra-particle diffusion kinetics for sorption of nitrate and Cr(VI) onto CS-T-PEI-P.

4. Kinetic studies of nitrate and Chromium(VI) adsorption onto CS-T-PEI-P

The experimental data were simulated by Lagergren pseudo-first order model (Eq. (S5)), pseudo-second order model (Eq. (S6)), Elovich equation (Eq. (S7)) and intra-particle diffusion model (Eq. (S8))[3-6].

$$\log\left(q_e - q_t\right) = \log q_e - k_1\frac{t}{2.303} \quad \text{(S5)}$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \quad \text{(S6)}$$

$$\mathrm{q}_t = \frac{1}{\beta}\ln\left(\alpha\beta\right) + \frac{1}{\beta}\ln\left(t\right) \quad \text{(S7)}$$

$$\mathrm{q}_t = \mathrm{k}_{id}\, t^{1/2} + C_i \quad \text{(S8)}$$

where q_e and q_t (mg.g^{-1}) are the amounts of the adsorbate sorbed per unit weight of sorbent at equilibrium and time t (min), respectively; k_1 (min^{-1}), k_2 (g (mg.min)$^{-1}$), and k_{id} (g.mg^{-1} min$^{-0.5}$) are the pseudo-first order rate constant, pseudo-second order equilibrium rate constant, and intraparticle diffusion rate constant, respectively; Elovich coefficients, α is the initial adsorption rate (mg (g.min)$^{-1}$) and β is the desorption constant (g.mg^{-1}) during any one experiment; C_i is the intercept of the plot of q_t against $t^{1/2}$, related to the thickness of the boundary layer.

Table S1: Kinetic parameters for the adsorption of NO_3^- and Cr(VI) onto CS-T-PEI-P at different initial concentrations (V=50 mL, m_{ads}=0.2 g, 300 rpm).

	NO_3^-			Cr(VI)		
	50 mg/L	100 mg/L	150 mg/L	50 mg/L	100 mg/L	150mg/L
$q_{e,\,exp}$ (mg/g)	**8.76**	**17.04**	**22.12**	**12.45**	**24.82**	**36.63**
Pseudo-first-order						
k_1(min^{-1})	0.019	0.020	0.023	0.017	0.017	0.017
$q_{e,cal}$(mg/g)	1.479	3.139	5.230	1.362	5.713	12.494
R^2	0.9805	0.9596	0.9713	0.9416	0.9602	0.9778
Pseudo-second-order						
k_2(g/mg.min)	0.055	0.027	0.016	0.049	0.010	0.004
$q_{e,cal}$(mg/g)	8.803	17.123	22.272	12.500	25.063	37.175
R^2	1.0000	1.000	1.000	1.0000	1.0000	1.0000
Elovich						
α(mg/g.min)	7.66×10^6	2.67×10^6	3.30×10^6	1.09×10^7	1.41×10^3	2.92×10^2
β(g/mg)	2.542	1.200	0.926	1.795	0.489	0.275

R^2	0.9126	0.8878	0.9551	0.7781	0.8272	0.9023
Intra-particle diffusion						
k_{1d}(mg/(g.min$^{1/2}$))	0.262	0.588	0.587	0.499	1.749	2.663
C_1(mg/g)	6.542	12.217	16.516	8.707	11.310	14.158
R^2_1	0.9278	0.9103	0.9095	0.8456	0.9129	0.9729
K_{2d}(mg/(g.min$^{1/2}$))	0.009	0.022	0.031	0.005	0.036	0.085
C_2(mg/g)	8.588	16.611	21.543	12.342	24.075	34.861
R^2_2	0.5569	0.4688	0.5341	0.8457	0.7210	0.8211

5. *Isotherm studies of nitrate and Chromium(VI) adsorption onto CS-T-PEI-P*

Different models of adsorption isotherm were tested to describe how CS-T-PEI-P interact with nitrate and chromate:

$$\ln q_e = lnK_F + \frac{1}{n_F} lnC_e \quad (S9)$$

$$\frac{C_e}{q_e} = \frac{1}{q_{max}K_L} + \frac{1}{q_{max}} C_e \quad (S10)$$

$$q_e = BlnA + BlnC_e \quad (S11)$$

$$\ln q_e = lnq_{max} - B_D\varepsilon^2 \quad (S12)$$

$$\varepsilon = RTln\left(1 + \frac{1}{C_e}\right) \quad (S13)$$

$$E = \frac{1}{\sqrt{2B_D}} \quad (S14)$$

Where q_e (mg.g^{-1}) and C_e (mg.L^{-1}) are the sorbate equilibrium concentrations in solid and the liquid phases; q_{max} (mg.g^{-1}), the monolayer capacity of the sorbent; K_L (L.mg^{-1}) is a constant of the Langmuir isotherm. K_F (L.g^{-1}) is Freundlich constant, and $1/n$ is the heterogeneity factor. B and A are the Temkin constants. B_D (mol^2/kJ^2) is the activity coefficient useful in obtaining the mean sorption energy E (kJ/mol) and $\mathcal{E}$ is the Polanyi potential. R is the gas constant (J/mol K) and T is the temperature (K).

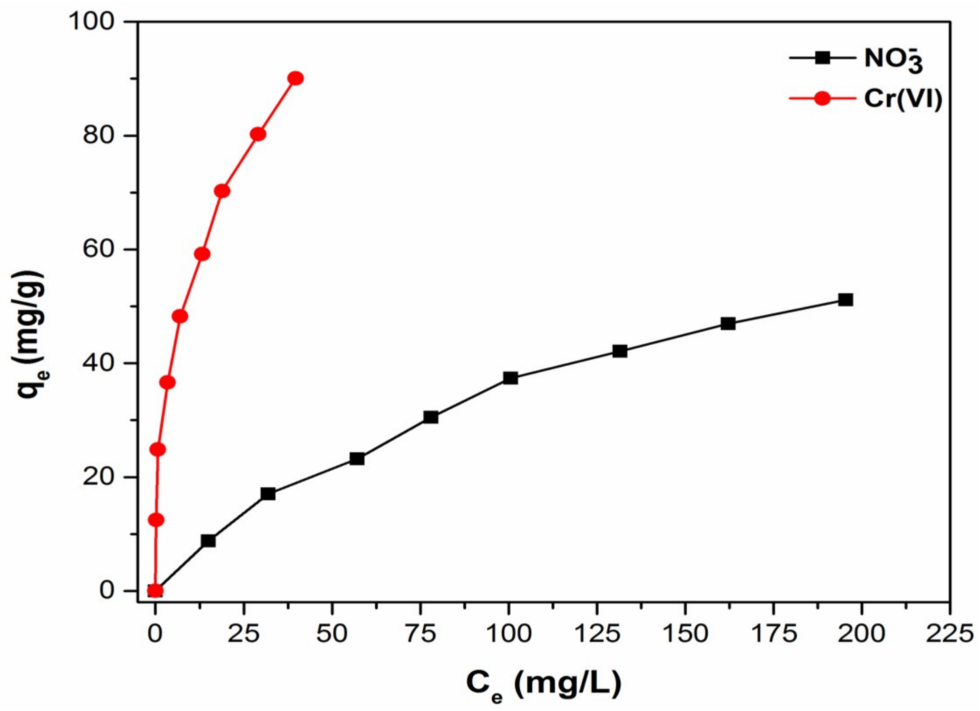

Figure S4: Effect of initial concentration of NO_3^- and Cr(VI) adsorption onto CS-T-PEI-P at equilibrium time (V = 50 mL; m_{ads} = 0.2 g; 300 rpm, initial pH).

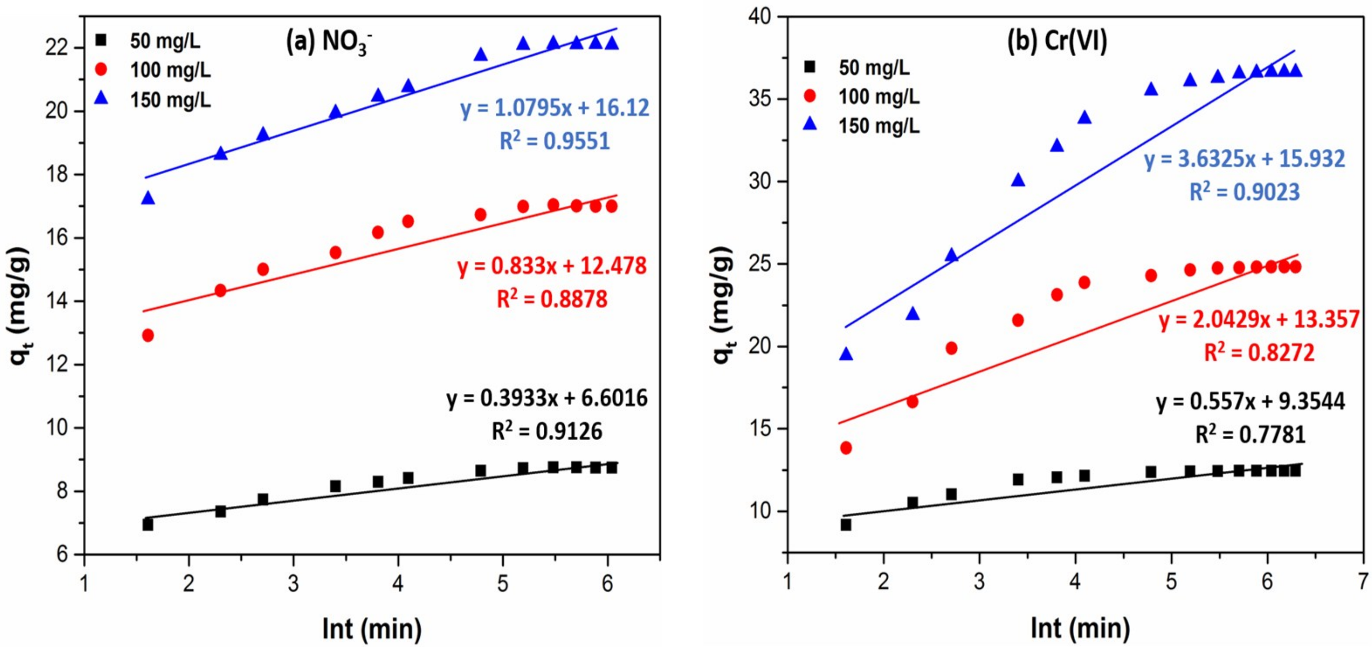

Figure S5. Elovich kinetic models of NO_3^- (a) and Cr(VI) (b) ions adsorption onto CS-T-PEI-P (m_{ads} = 0.2 g, initial pH, 300 rpm, V = 50 mL and room Temperature).

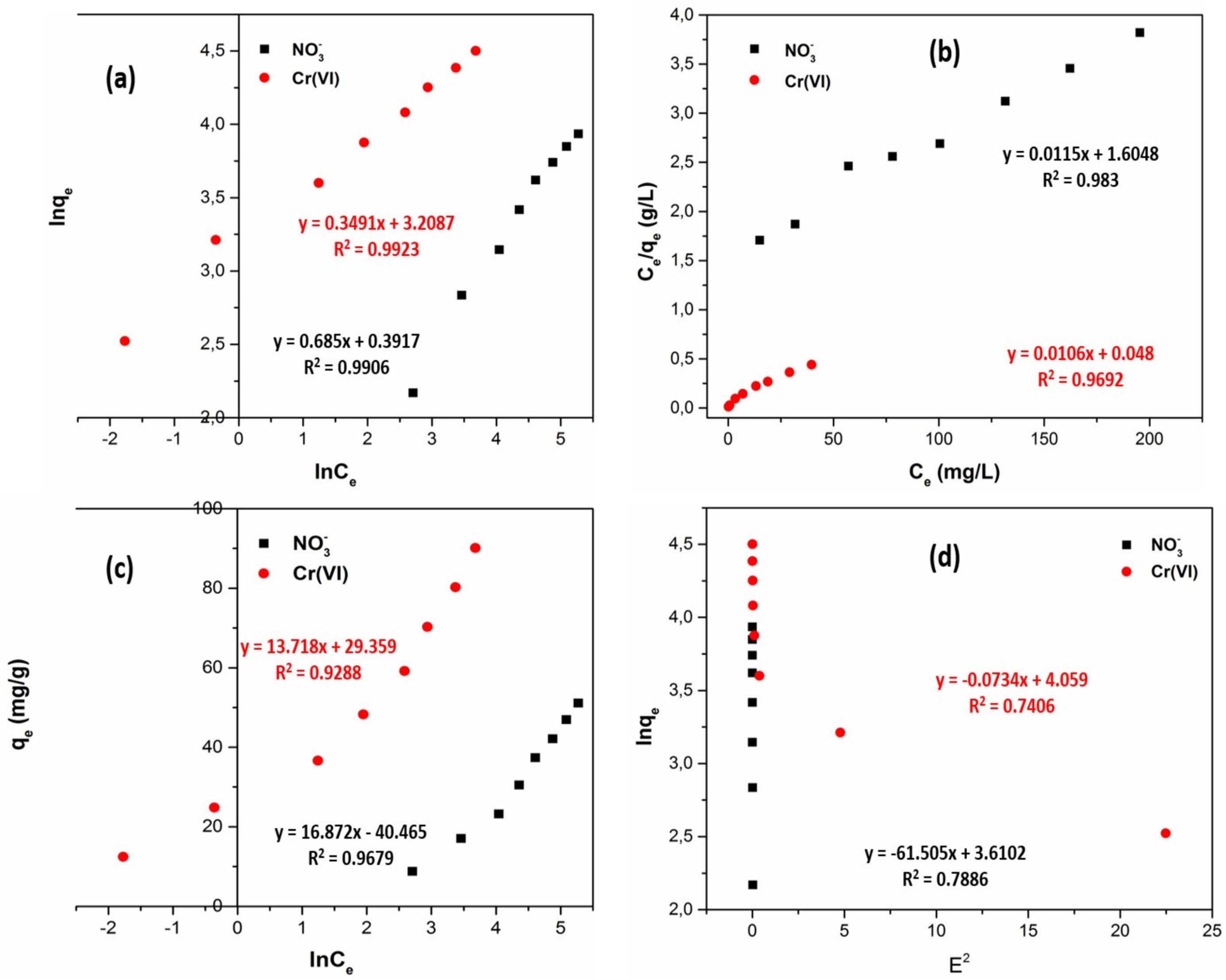

Figure S6. Equilibrium adsorption Isotherms, (a) Freundlich, (b) Langmuir, (c) Temkin and Dubinin-Radushkevich (d) models of NO$_3^-$ and Cr(VI) ions adsorption onto CS-T-PEI-P (m$_{ads}$ = 0.2 g, initial pH, 300 rpm, V = 50 mL and room Temperature).

Table S2: Isotherm parameters for the adsorption of NO_3^- and Cr(VI) into CS-T-PEI-P ($V=50$ mL, $m_{ads}=0.2$ g, 300rpm).

Isotherm models	**NO_3^-**	**Cr(VI)**
Freundlich		
K_F(mg/g)(L/mg)$^{1/n}$	1.479	24.747
n_F	1.460	2.864
R^2	0.9906	0.9923
Langmuir		
K_L(L/mg)	0.007	0.221
q_{max}(mg/g)	86.956	94.340
R^2	0.9830	0.9692
Temkin		
A(L/mg)	0.091	8.501
B(J/mol)	16.872	13.718
R^2	0.9679	0.9288
Dubinin-Radushkevich		
q_{max}(mg/g)	37.040	57.916
E (kJmol^{-1})	0.090	2.610
R^2	0.7886	0.7406

6. Thermodynamic studies of nitrate and Chromium(VI) adsorption onto CS-T-PEI-P

Thermodynamic parameters were determined using the following equation:

$$K_c = \frac{C_{ad,e}}{C_e} \quad (S15)$$

$$\ln K_c = \frac{\Delta S°}{R} - \frac{\Delta H°}{RT} \quad (S16)$$

$$\Delta G° = \Delta H° - T\Delta S° \quad (S17)$$

Where K_c is the distribution coefficient for the adsorption, $C_{ad,e}$ is the amount of NO_3^- or Cr(VI) (mg) adsorbed on the adsorbent per liter of solution at equilibrium, and C_e is the equilibrium concentration (mg/L) of the pollutants in solution. R (8.314 J/mol K) is the universal gas constant and T (K) is the solution temperature.

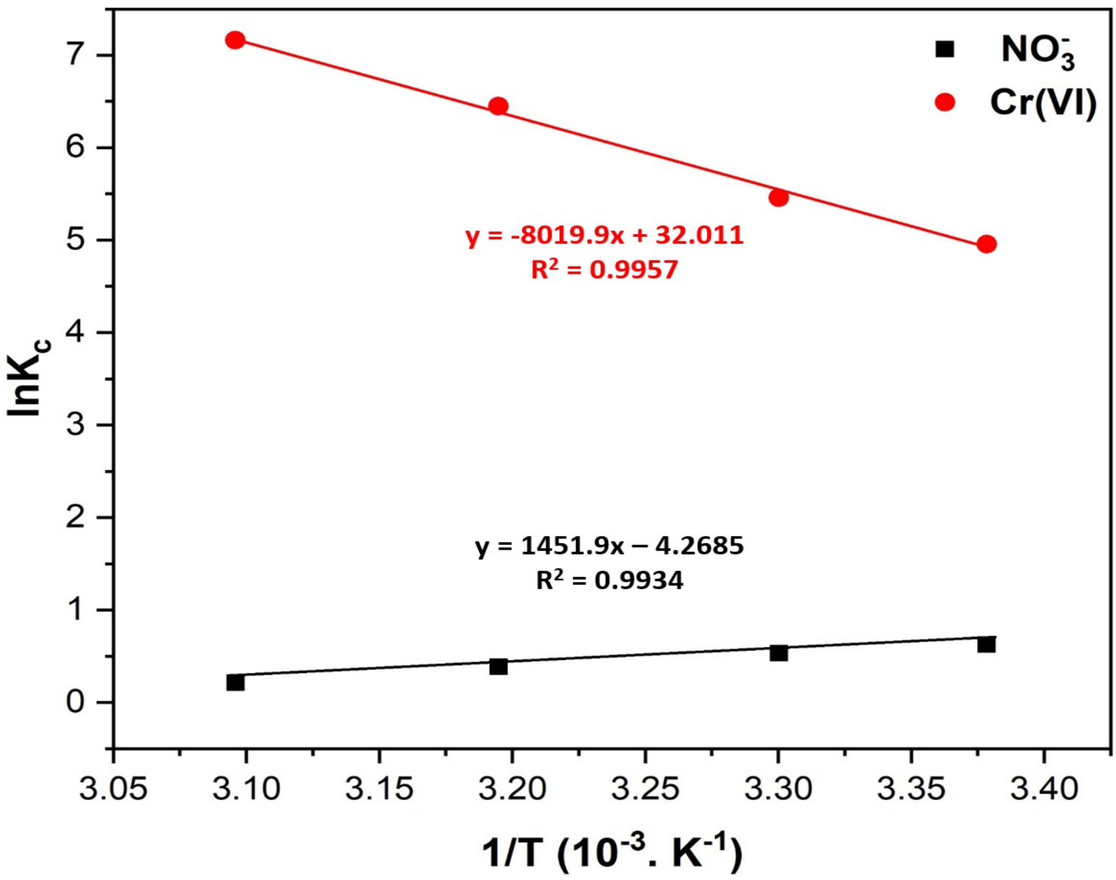

Figure S7. Thermodynamic parameters of NO_3^- (a) and Cr(VI) (b) ions adsorption onto CS-T-PEI-P (m_{ads} = 0.2 g, initial pH, 300 rpm, V = 50 mL and C_i = 100 mg/L).

7. Adsorption thermodynamics

Table S3: Thermodynamic constants for the adsorption of NO_3^- and Cr(VI) onto CS-T-PEI-P (V=50 mL, m_{ads}=0.2 g, 300 rpm).

		ΔH°(kJ.mol^{-1})	**ΔS°(J.K^{-1}mol^{-1})**	**ΔG°(kJ.mol^{-1})**			
	R²			**296K**	**303K**	**313K**	**323K**
NO_3^-	0.9934	- 12.071	- 35.488	- 1.566	- 1.318	- 0.963	- 0.608
Cr(VI)	0.9957	66.677	266.139	-12.100	- 13.963	- 16.624	- 19.285

<u>References:</u>

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