Supplementary Materials

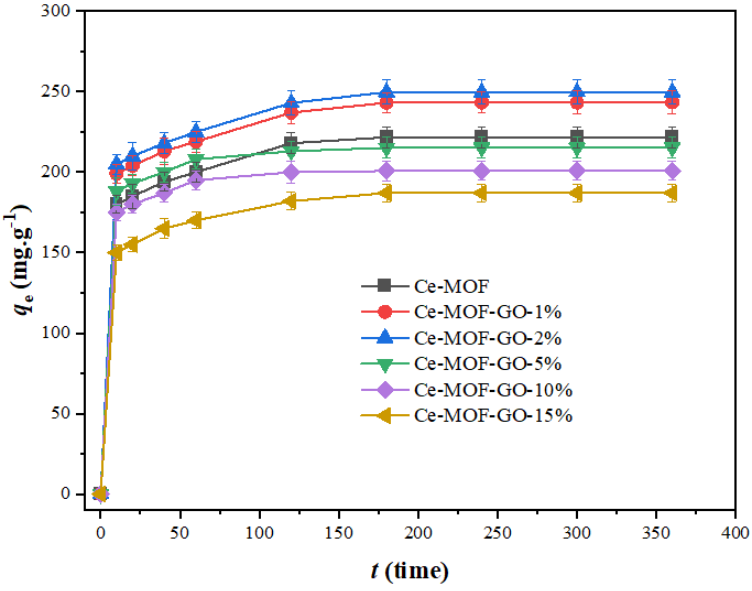

Fig. S1. effect of different GO adding ratios on phosphate adsorption by Ce-MOF-GO composite with initial concentration of 100 mg L^{-1}.

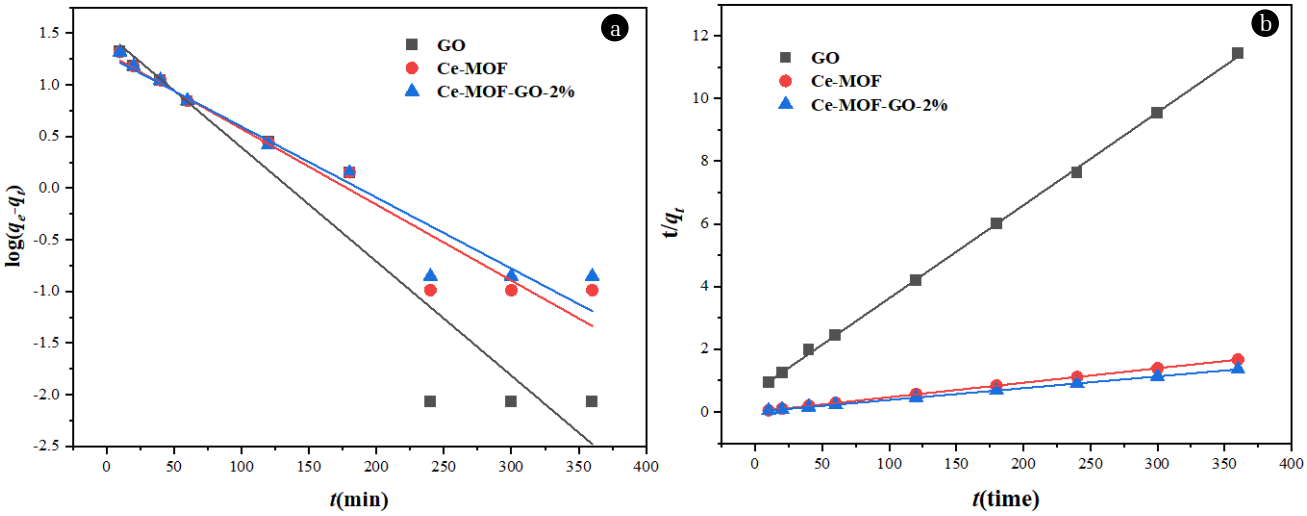

Fig. S2. Kinetic model plots (a, first pseudo-order) (b, second pseudo-order) for the adsorption of phosphate onto the adsorbents

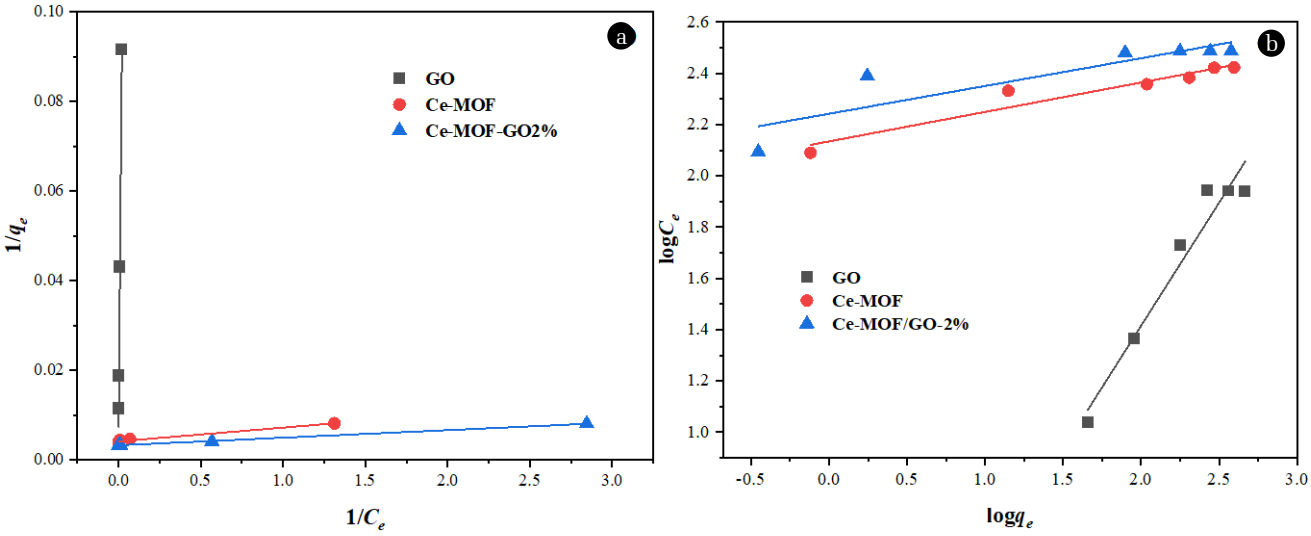

Fig. S3. Langmuir (a) and Freundlich model of isotherm(b) for the phosphate adsorption

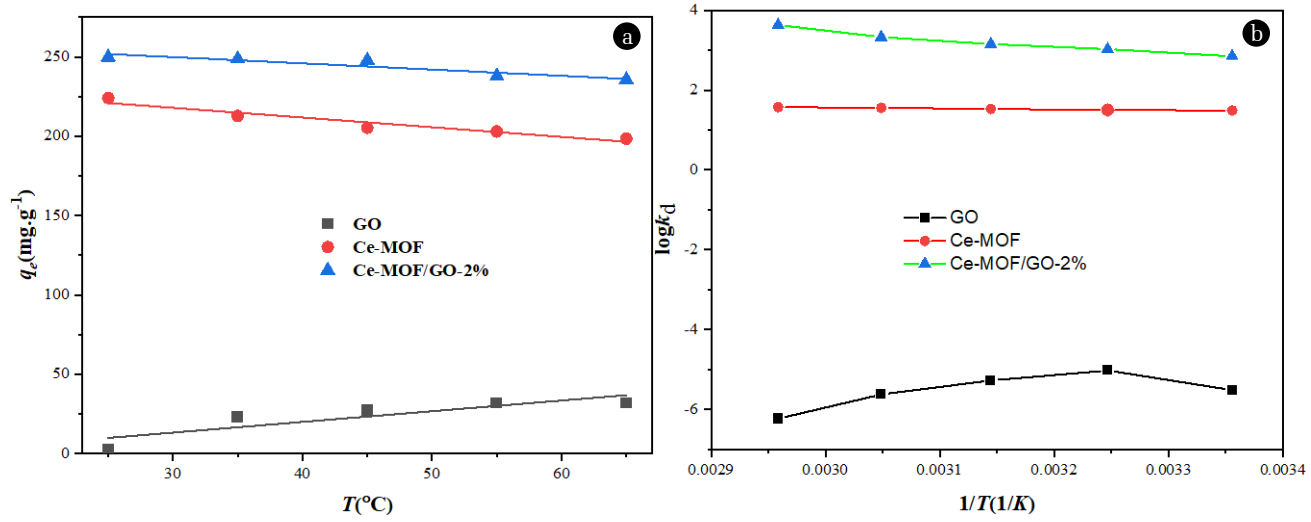

Fig. S4. effect of various temperatures (a) and adsorption thermodynamic (b) with initial concentration100 mg L^{-1}

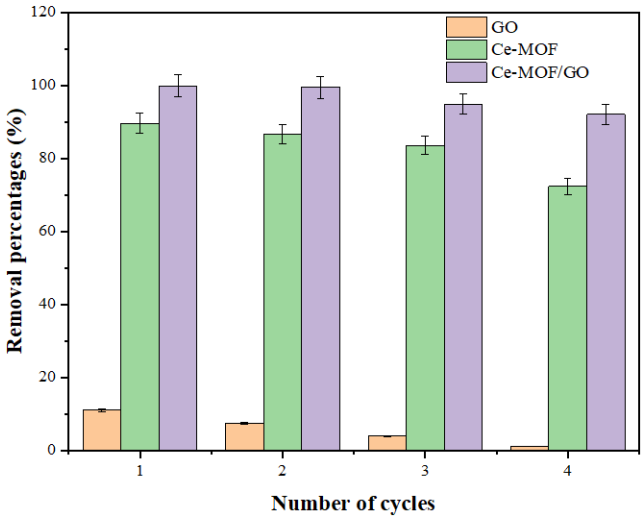

Fig. S5. Reusability of Ce-MOG/GO-2% composite onto phosphate adsorption.

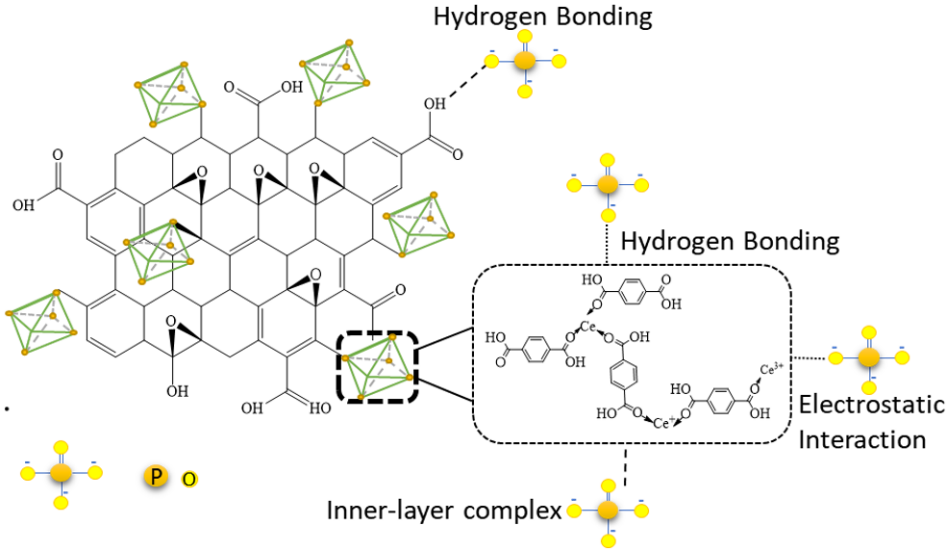

Fig. S6. The possible adsorption mechanism of phosphate by the adsorbent

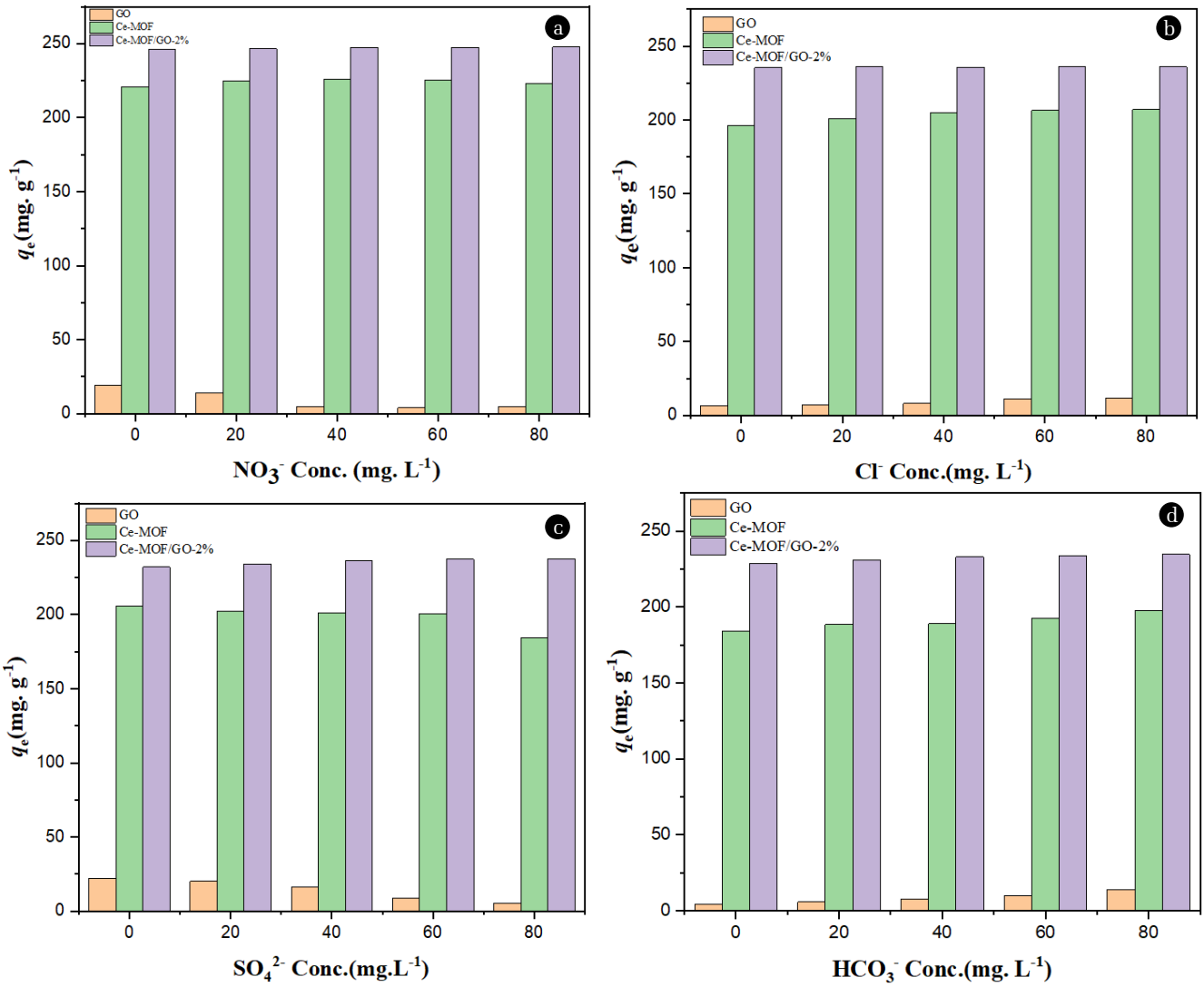

Fig. S7. Effect of coexisting ions (P.conc. 100 mg L^{-1}) on phosphate removal by the adsorbents

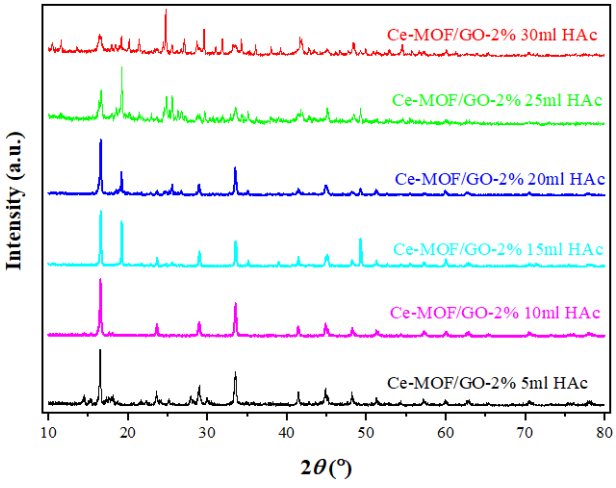

Fig. S8. XRD patterns of the samples with various HAc addition in Ce-MOF/GO-2% composite material.

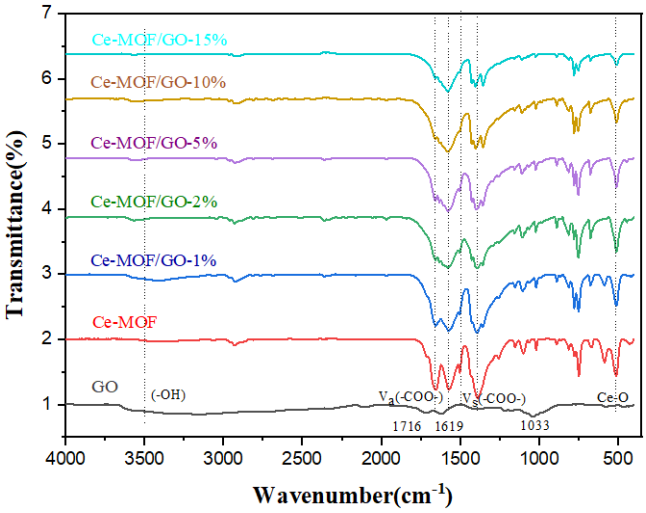

Fig. S9. FT-IR spectra images of the samples with adding various amount of GO.

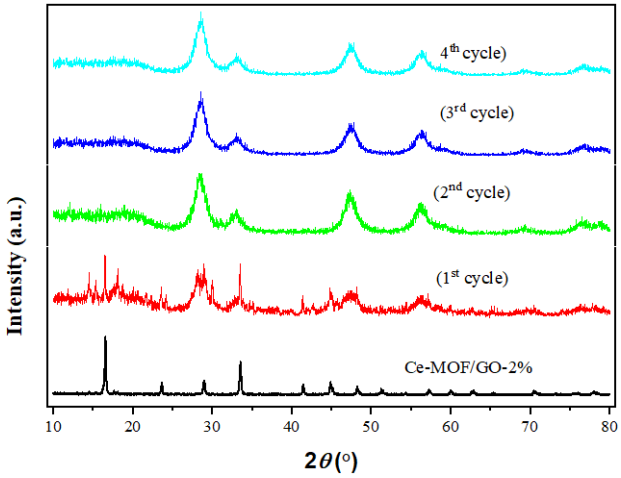

Fig. S10. XRD patterns of the sample after four adsorption desorption cycles

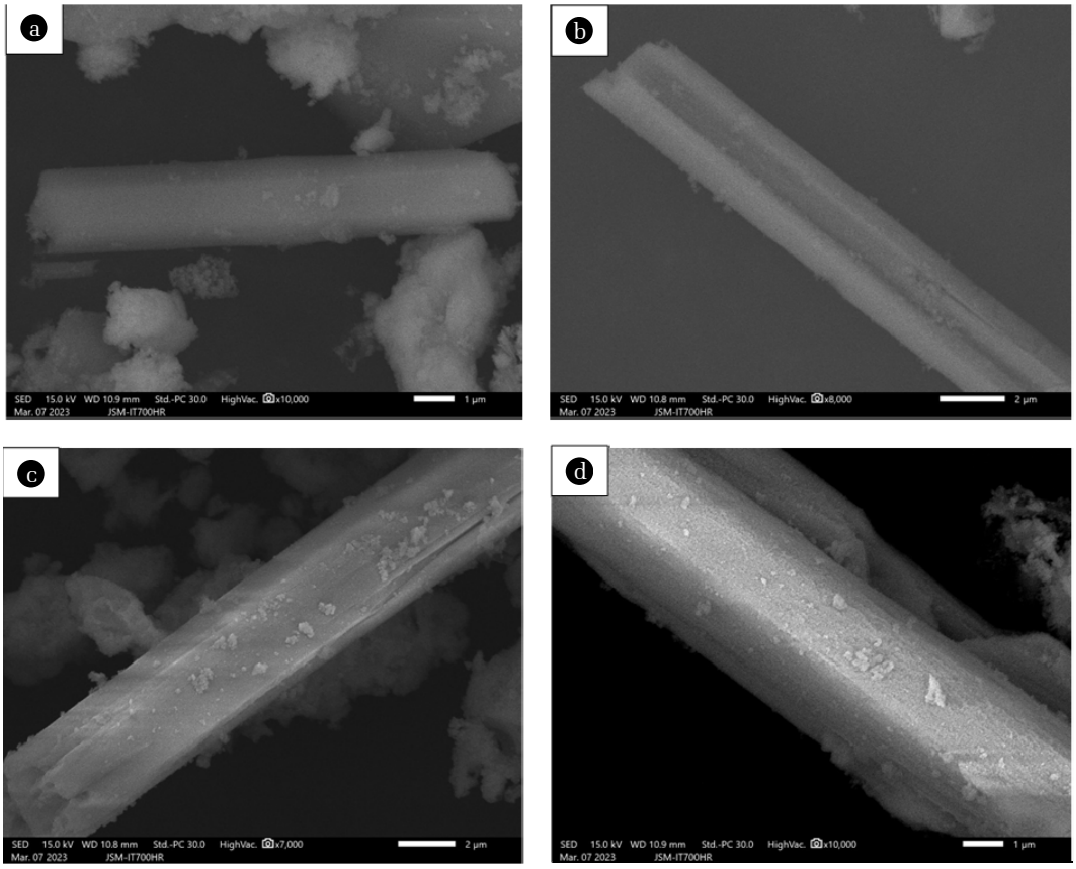

Fig. S11. SEM images of the sample after four adsorption desorption cycles, first (a) second (b) third (c) forth (d) cycles, respectively.

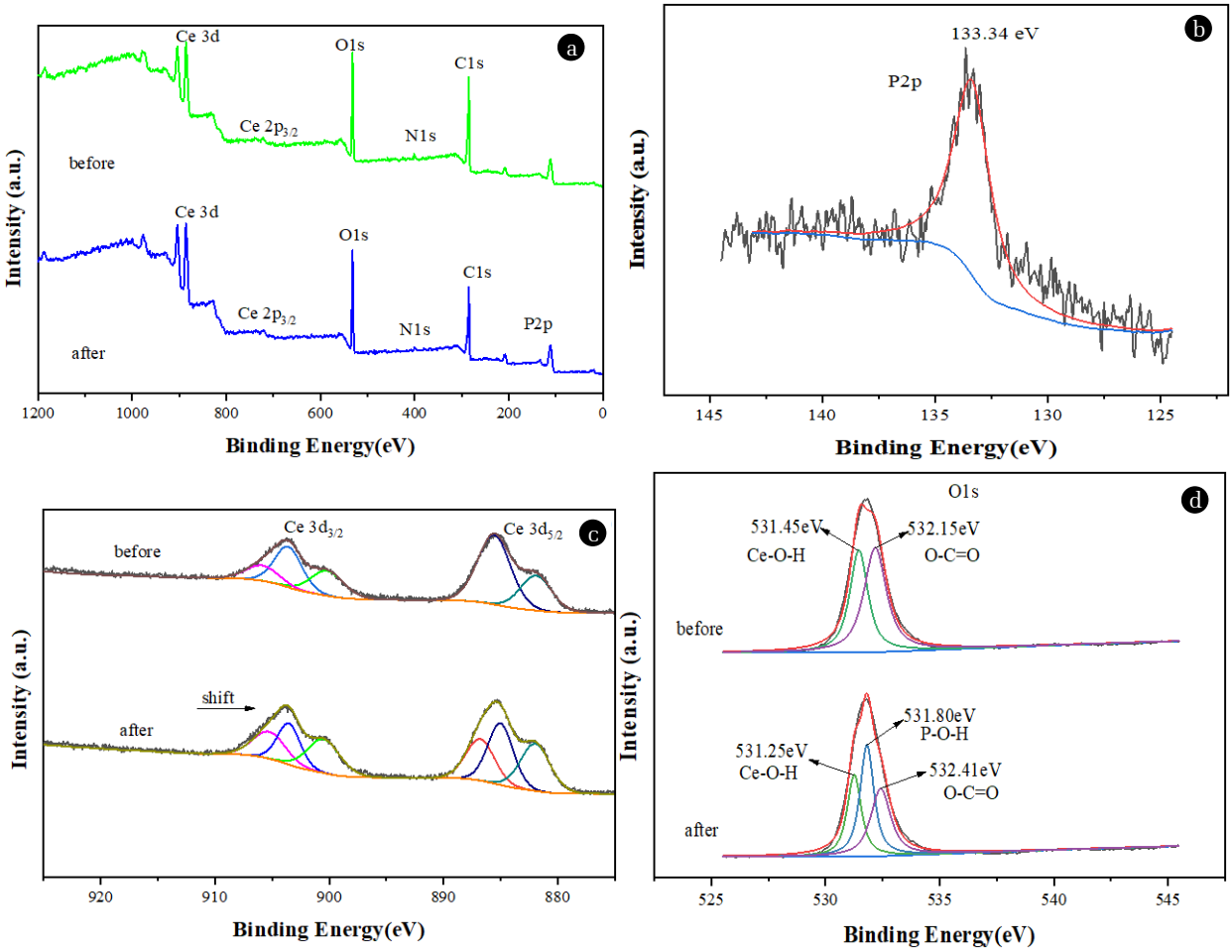

Fig. S12. XPS spectra of Ce-MOF/GO-2% before and after phosphate adsorption, wide-scan spectra (a) P2p (b) Ce 3d(c) O1s (d), respectively.

Table S1. specific surface area and pore structure characteristics of the adsorbents

Adsorbents	S_{BET} ($m^2.g^{-1}$)	V_p ($cm^3.g^{-1}$)	D_p (nm)
GO	3.986	0.018	1.070
Ce-MOF	257.498	0.144	0.645
Ce-MOF/GO-2%	46.679	0.078	6.752

Table S2. Adsorption kinetic models for phosphate adsorption by the adsorbents

Adsorbent	C_0 (mg. L^{-1})	q_e (mg. g^{-1})	Pseudo-first-order			Pseudo-second-order		
			K_1(min^{-1})	$q_{e,c}$(mg. g^{-1})	R^2	K_2.g.mg^{-1}.min^{-1}	$q_{e,c}$(mg. g^{-1})	R^2
GO	130	31.43	0.022	31.5	0.899	0.005	33.726	0.910
Ce-MOF	130	215.6	0.014	20.36	0.932	0.002	216.919	0.999
Ce-MOF/GO-2%	130	264.7	0.013	19.27	0.933	0.002	265.957	0.999

Table S3. The Langmuir and Freundlich isotherms parameters for phosphate adsorption

Adsorbents	Langmuir isotherm			Freundlich isotherm		
	Q^0/ (mg g^{-1})	b/(L.mg^{-1})	R^2	K_F	1/n	R^2
GO	67.84	0.006	0.992	2.775	0.481	0.909
Ce-MOF	244.49	1.323	0.963	136.376	0.114	0.907
Ce-MOF/GO-2%	308.64	1.917	0.998	174.823	0.108	0.722

Table S4. Comparison of Ce-MOF/GO-2% with other adsorbents

NO	Adsorbents	P. C_0 (mg. L^{-1})	A.E. T(min)	M.A.C. (mg. g^{-1})	Reference
1	Ce (III) – MOF	100-500	200	189.4	[36]
2	UiO-66-NH_2@La $(OH)_3$	20-800	150	140.7	[71]
3	Fe_3O_4/NH_2-La-MOF	10-100	360	111.2	[3]
4	NH2-MIL-101 MOFs	5-100	120	79.4	[79]
5	UiO-66-NH2	1010	1440	153.9	[4]
6	Al-MIL-101	5-200	100	90	[71]
7	ZIF-8	5-20	60	38.22	[72]
8	La-MOFs	10-200	80	142	[73]
9	La-CAU-17 MOF	10-800	420	216	[74]
10	Fe-Al- MOF	30-100	240	38.33	[75]
11	Al-MOF	20-80	120	97.15	[76]
12	Fe/Al (NO_3^-) MOF	5-200	50	130	[68]
13	Graphene oxide	125	50	195.6	[54]
14	La-AmGO@AmCs microspheres	20-100	60	125	[77]
15	GO@AgNPs	30	20	11.2	[78]
16	Zeolitic imidazolate framework 67 (ZIF-67	30	40	92.4	[79]
17	Ce-MOF	500	180	244.4	This work
18	Ce-MOF/GO-2%	500	180	308.6	This work

P= phosphate, C_0 = Initial concentration, A.E. T= adsorption equilibrium time, M.A.C= maximum adsorption capacity

Table S5. Thermodynamic adsorption parameters of phosphate onto the adsorbents

Adsorbent	T(K)	ΔG^0/(kJ.mol^{-1})	ΔH^0/(kJ.mol^{-1})	ΔS^0/ [J. (k. mol^{-1})]$^{1-}$	R^2
	298	9.124			
	308	3.517			
GO	318	3.117	-0.005	-58.446	0.685
	328	2.755			
	338	2.839			
	298	-7.614			
	308	-6.812			
Ce-MOF	318	-6.455	0.005	1963.860	0.902
	328	-6.488			
	338	-6.363			
	298	-20.708			
	308	-15.764			
Ce-MOF/GO-2%	318	-14.916	0.003	2175.180	0.818
	328	-10.608			
	338	-10.439			

Table S6. Comparation of GO, GO composite and MOFs adsorbents reusability

No	Adsorbents	Phosphate C_0 (mg. L^{-1})	pH	Removal Percentage				Ref.
				1st cycle	2nd cycle	3rd cycle	4th cycle	
1	GO–Fe_2O_3	50	6	79	62	36	20	[80]
2	TATGO@Alg composite beads	100	7	99	95	90	82	[81]
3	TETA-MGO/CS	-	3	93.9	84	82	73	[82]
4	F-G-F composite	15	3	60.67	55	37	21.25	[83]
5	GO/MIL-101(Fe-Cu) composite	100	2.8	96.11	85	80	72.13	[21]
6	L-GO/MgMn-LDH-300 composite	50	3	85.8	81	>80	-	[84]
7	Ce-MOF/GO-2%	100	3-6	99.8	99.4	94.9	92	This work