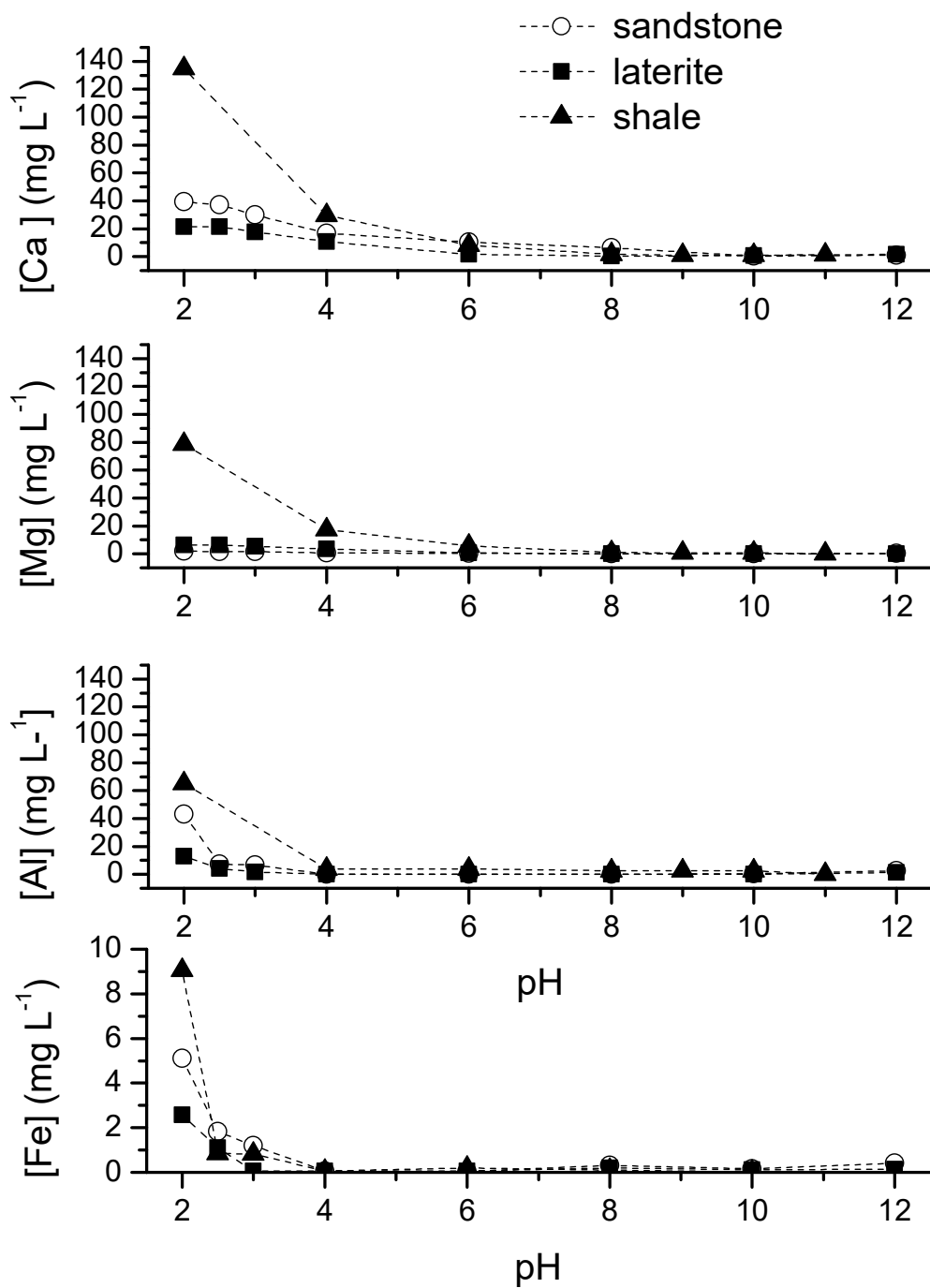**Fig. S1:** Ion concentrations in solution in blank experiments (without PO_4) as a function of pH ([adsorbent] = 80 g·L^{-1}; time contact: 24 h).

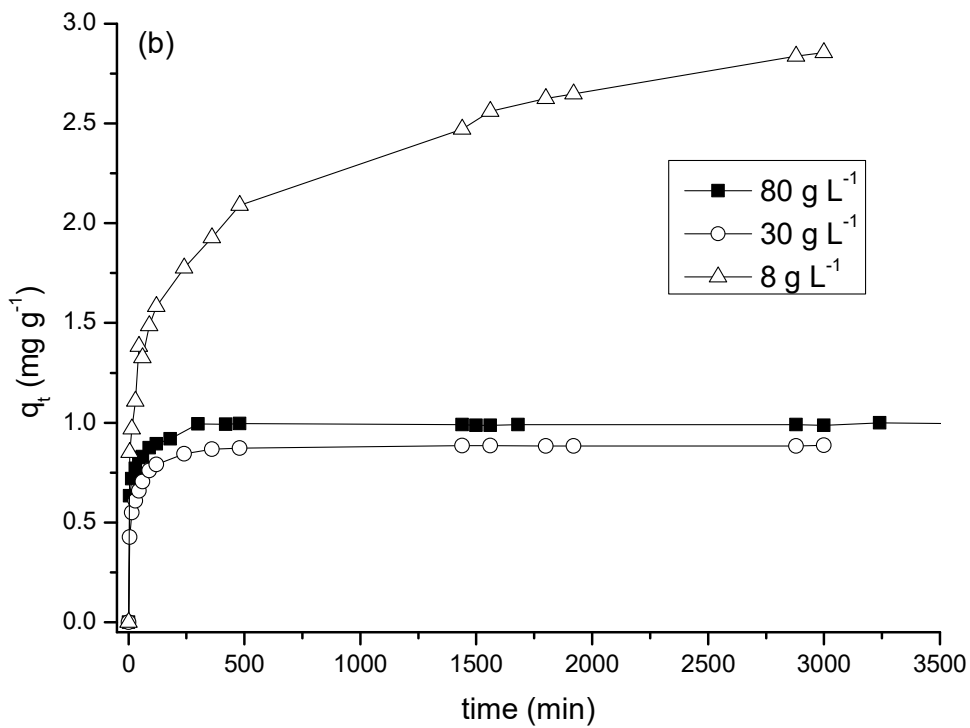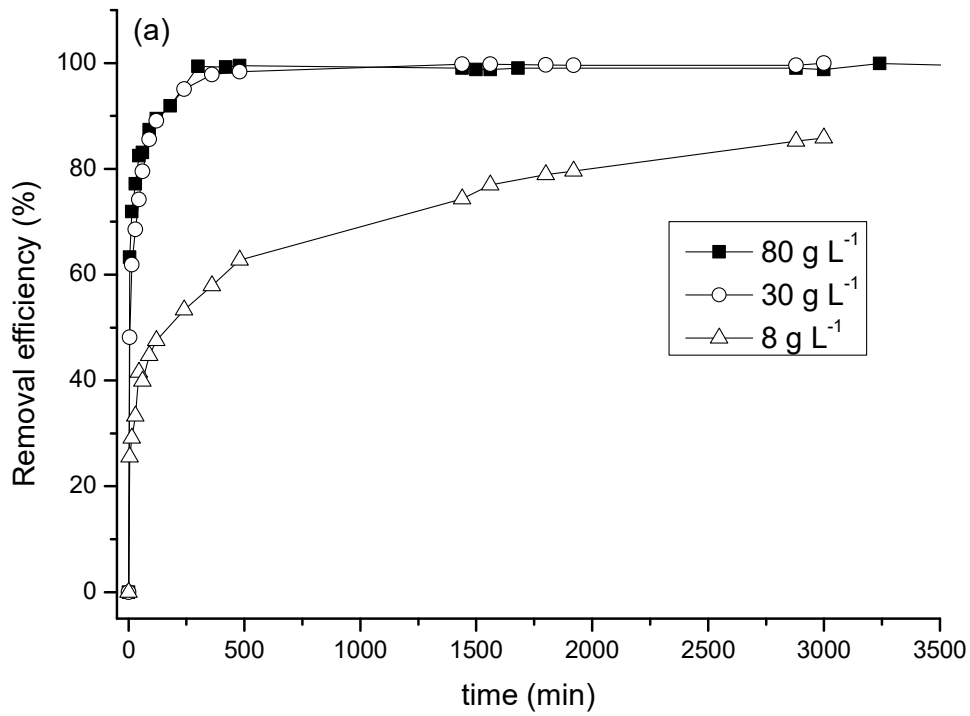**Fig S2:** Effect of contact time and sandstone dose on phosphate removal efficiency (a) and phosphate uptake (b) ($[PO_4]_{initial} = 25$ mg·L^{-1}; contact time: 24 h; granular fraction < 400 μm).
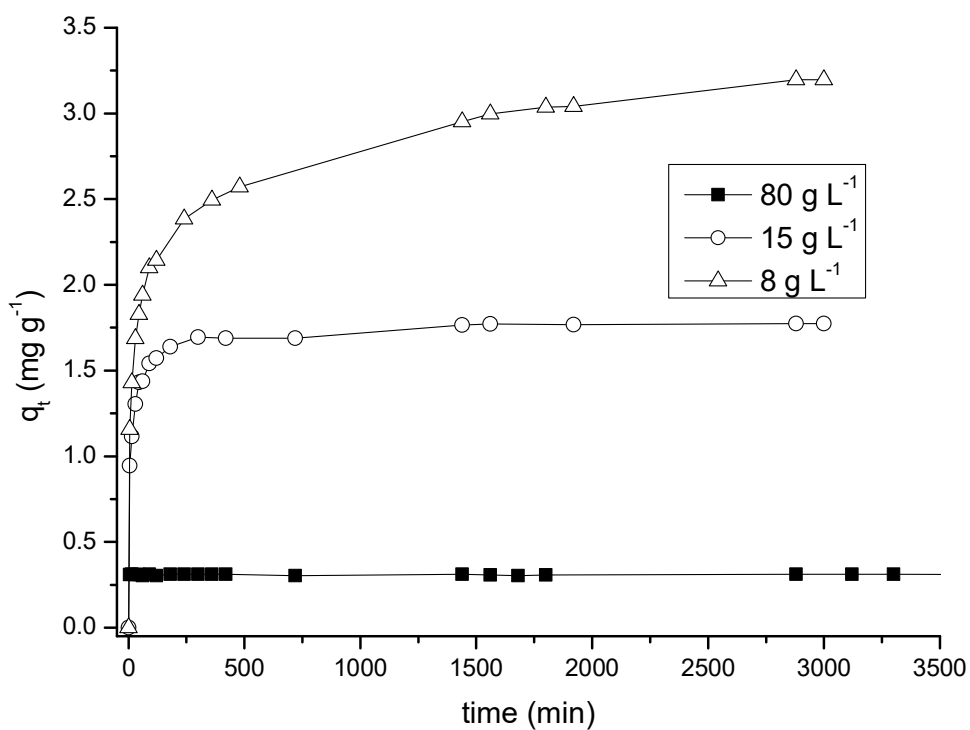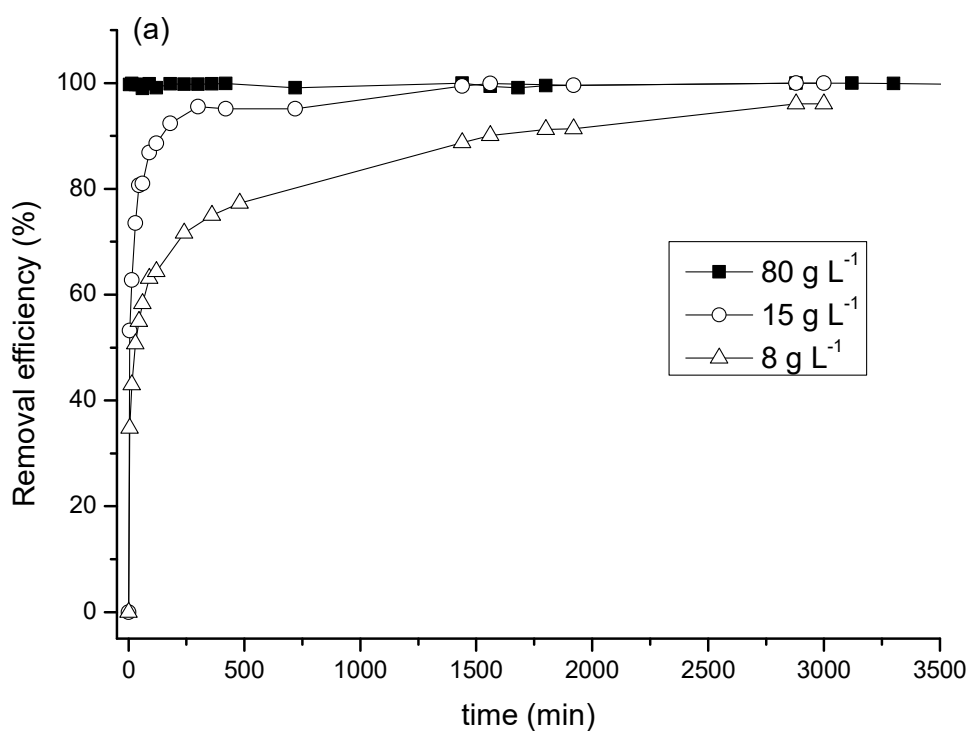
Fig S3: Effect of contact time and laterite dose on phosphate removal efficiency (a) and phosphate uptake (b) (Sorbent dose = 80 g·L^{-1}; [PO$_4$]$_{initial}$ = 25 mg·L^{-1}; pH ~ 7; contact time: 24 h; granular fraction < 400 μm)).
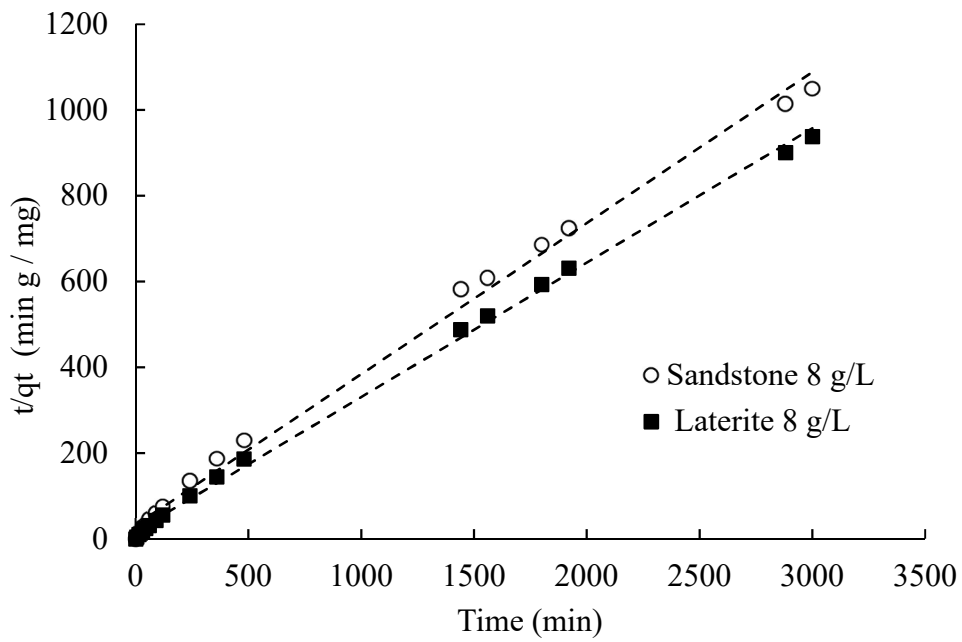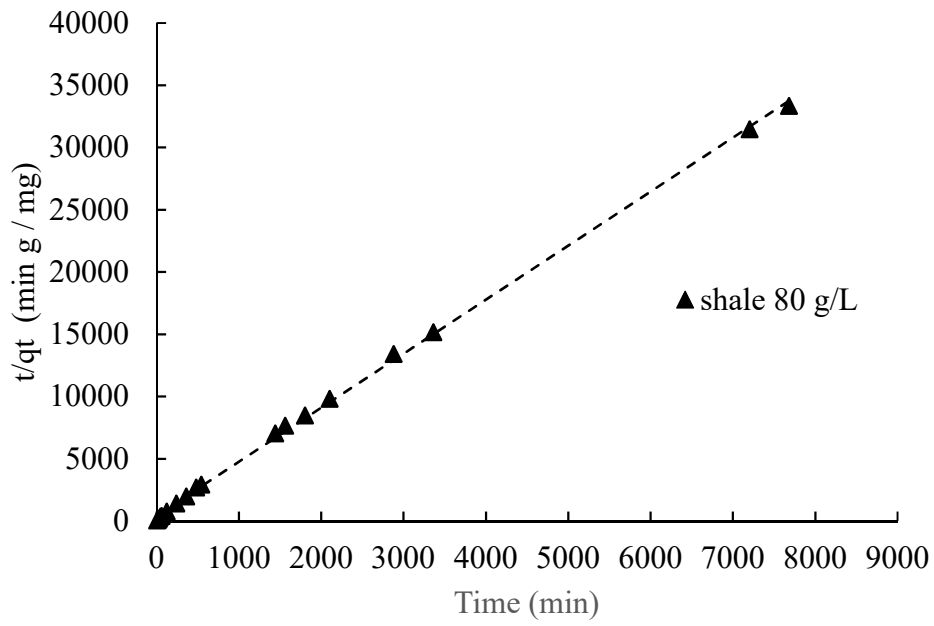
Fig. S4: Kinetics modelling of phosphate sorption onto shale (80 g/L) and sandstone and laterite (8 g/L) using a pseudo-second order model ($[PO_4]_{initial} = 25$ mg·L^{-1}; pH ~ 7; time contact: 24 h).
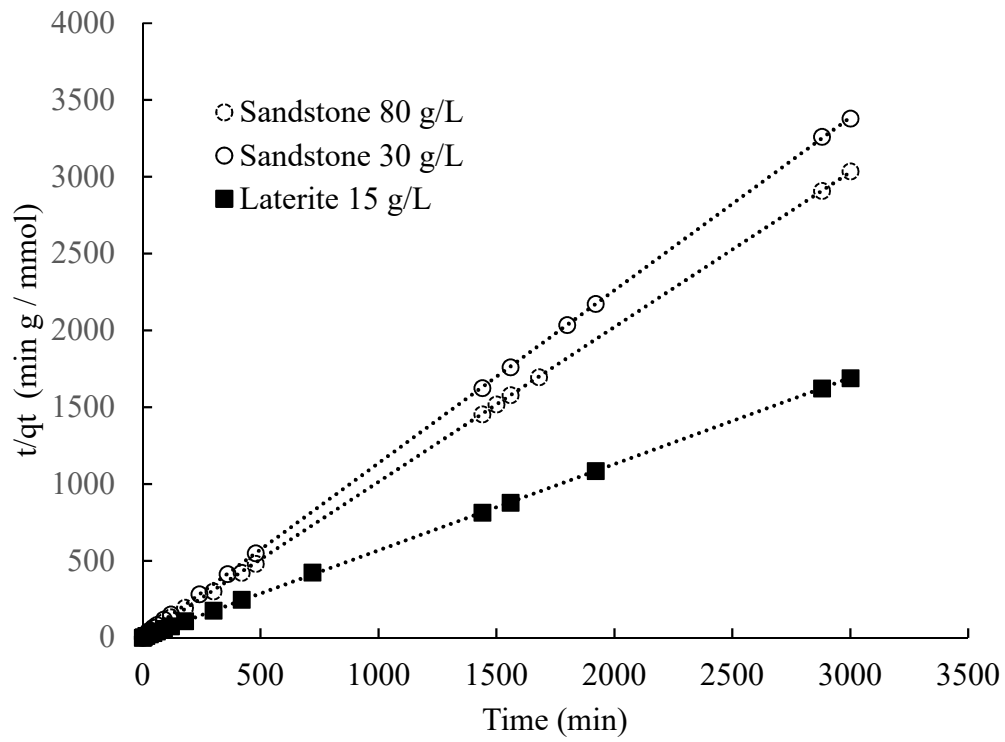
Fig. S5: Kinetics modelling of phosphate sorption onto sandstone (80 and 30 g/L) and laterite (15 g/L) using pseudo-second order model ($[PO_4]$ = 25 mg·L^{-1}; pH ~ 7; time contact: 24 h).
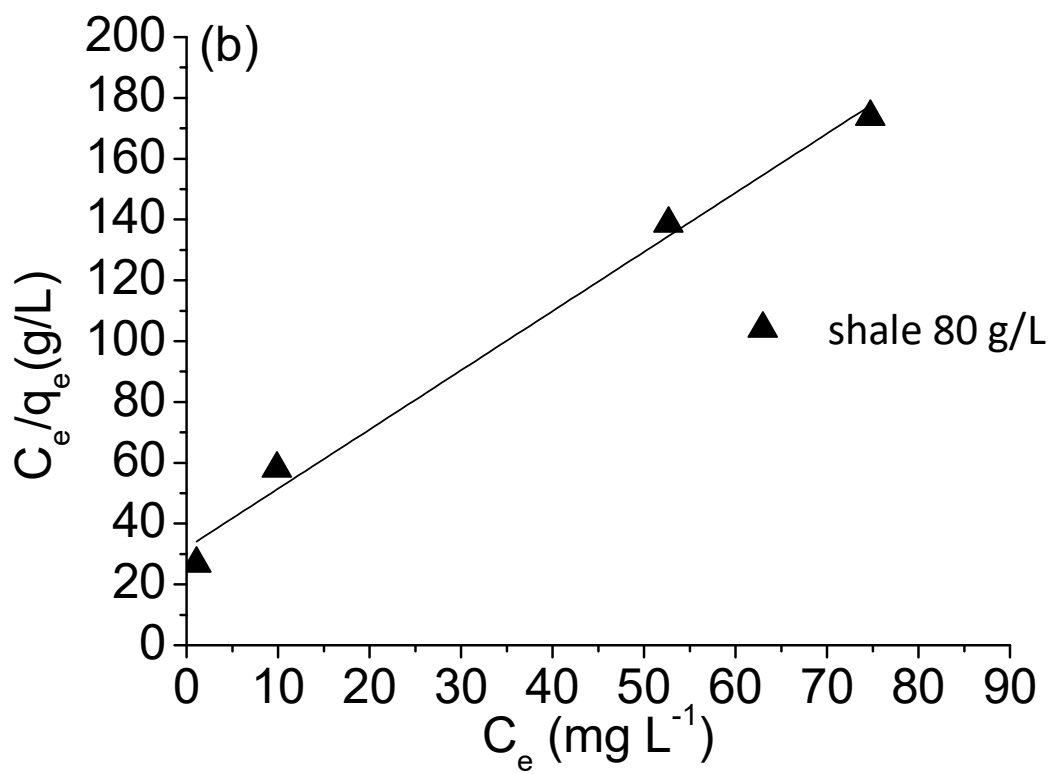
Fig. S6: Langmuir plot for phosphate sorption onto shale (b); (pH ~ 7; time contact: 24 h).

Table S1 - Physical parameters of naturally occurring sandstone, laterite and shale samples from Ivory Coast. The porosity was determined in triplicate by a volumetric method which consisted to determine the volume of water (V_w) required to saturate a known volume of shale (V_s). The porosity (ε) was obtained according the following formula $\varepsilon = V_w/V_s \times 100$. The particle-size distribution, on a weight basis was analyzed in triplicate by conventional dry-sieving techniques. The grain-size distribution plots were used to estimate d_{10} and d_{60} (10% and 60% of the material by weight is smaller than d_{10} and d_{60}, respectively). The uniformity of the particle-size distribution (the uniformity coefficient (CU)) was calculated as the ratio of d_{60} to d_{10}.

Materials (1–2 mm)	Physical characteristics							
	d_{10} (mm)	d_{60} (mm)	Average particle size (mm)	CU	Porosity (%)	Bulk density	Apparent density (g·cm^{-3})	K^* (m·s^{-1})
Sandstone	1.87	0.97	1.21	0.52	52	2.60	1.26	$3.5.10^{-2}$
Laterite	1.84	1.03	1.17	0.56	51	2.35	1.15	$3.4.10^{-2}$
Shale	1.80	0.95	1.14	0.53	50	2.40	1.14	$3.2.10^{-2}$

*Saturated hydraulic conductivity

Table S2 - Chemical composition (wt %) of naturally occurring shale, sandstone and laterite samples from Ivory Coast.

	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LoI*
Shale	56.8	17.5	10.2	0.6	2.1	0.4	0.9	2.4	1	0.1	8.7
Sandstone	29.3	6.3	54.4	<L.D.	<L.D.	0.1	<L.D.	0.1	0.3	1.0	8.7
Laterite	50.3	14.0	24.5	0.1	0.08	0.08	0.02	0.3	0.7	0.1	9.9

*Loss on ignition

Table S3 - Mössbauer hyperfine parameters of the spectra of sandstone and laterite presented in Fig. 2. CS: center shift with respect to α-Fe at room temperature; Δ: quadrupole splitting or ε: quadrupole shift ; H: hyperfine magnetic field, and RA: Relative Area.

Name	Component	CS	Δ or ε	H	RA
		$(\text{mm}\cdot\text{s}^{-1})$	$(\text{mm}\cdot\text{s}^{-1})$	(kOe)	(%)
Sandstone	D1 (α-FeOOH)	0.32	1.07	–	19
	S1 (α-FeOOH)	0.41	–0.17	290	41
	S1 (Fe_2O_3)	0.37	–0.04	491	40
Laterite	D1 (α-FeOOH)	0.34	0.55	–	55
	S1 (α-FeOOH)	0.35	–0.26	340	6
	S1 (Fe_2O_3)	0.66	–0.1	500	20
	S1 (Fe_2O_3)	0.36	–0.09	476	19

Table S4 - Mössbauer hyperfine parameters of the spectra of shale, sandstone and grey presented in Fig. 3. CS: center shift with respect to α-Fe at room temperature; Δ: quadrupole splitting or $\mathcal{E}$: quadrupole shift; H: hyperfine magnetic field, and RA: relative Area.

Name	T (K)	Component	CS (mm·s^{-1})	Δ or $\mathcal{E}$ (mm·s^{-1})	H (kOe)	RA (%)
Shale	12	D1 (Fe^{3+})	0.470	0.836	–	55
		D2 (Fe^{2+})	1.272	2.71	–	14
		S1 (α-FeOOH)	0.6	–0.2	480	23
		S2 (α-FeOOH)	0.56	–0.08	500	8
Sandstone	9	S1 (α -FeOOH)	0,48	–0.12	497	51
		S2 (Fe_2O_3)	0,48	–0.08	532	49
Laterite	9	S1 (α-FeOOH)	0.46	–0.12	502	28
		S2 (α-FeOOH)	0.46	–0.12	487	32
		S3 (Fe_2O_3)	0.46	–0.09	532	40
		D1 (Fe(III)))				3

Table S5 - Kinetic models parameters for phosphate adsorption on laterite, sandstone and shale after reaction with an initial phosphate concentration of 25 mg·L^{-1}.

Material	Dose (g·L^{-1})	q_{exp} (mg·g^{-1})	Pseudo-first-order kinetic model (Eq. (3))			Pseudo-second-order kinetic model (Eq. (4))		
			q_{calc} (mg·g^{-1})	k_1 (min^{-1})	R^2	q_{calc} (mg·g^{-1})	k_2 (g·mg^{-1}·min^{-1})	R^2
Laterite	15	1.70	0.41	0.01	0.703	1.78	0.041	0.999
	8	3.2	1.31	0.01	0.926	3.2	0.006	0.998
Sandstone	80	0.99	0.29	0.01	0.927	0.99	0.51	1.000
	30	0.87	0.48	0.02	0.963	0.89	0.10	1.000
	8	2.8	1.80	0.01	0.800	2.84	0.01	0.990
Shale	80	0.21	0.07	0.01	0.955	0.23	0.04	0.999

Table S6 - Langmuir and Freundlich isotherm parameters for phosphate adsorption on shale (pH ~ 7; [shale] = 80 g/L; contact time: 24 h).

Model	Equation	Parameters	
Langmuir	$\dfrac{C_e}{q_e} = \dfrac{C_e}{q_m} + \dfrac{1}{K_L\, q_m}$	R^2	0.995
		q_m (mg/g)	0.514
		K_L (L/g)	0.061
Freundlich	$\ln(q_e) = \ln(K_f) + \dfrac{1}{nf}\ln(C_e)$	R^2	0.955
		n_f	2.02
		K_f (L/g)	0.046