S1. Calculation of DLVO interaction energy

According to Derjaguin–Landau–Verwey–Overbeek (DLVO) theory, the total interaction energy (V_{TOT}) between PS-NPs and collector could be expressed as the sum of two interactions, namely the attractive van der Waals interaction (V_{VDW}) and the repulsive electrostatic double layer interaction (V_{EDL}) (Hogg et al., 1966):

$$V_{TOT} = V_{VDW} + V_{EDL} \tag{S1}$$

The van der Waals interaction was calculated using the Hamaker approach and Gregory's formulation (Gregory, 1981):

$$V_{VDW} = -\frac{A r_{NP}}{6h(1+\frac{14h}{\lambda})} \tag{S2}$$

Where A is the Hamaker constant for the system PS-NPs-water-quartz sand (9.25×10^{-21} J); r_{NP} is the radius of PS-NPs (100 nm); h is the separation distance between PS-NPs and quartz surface; λ is the characteristic wavelength of PS-NPs (λ = 220 nm).

The electrical double layer interaction was calculated as (Elimelech and O'Melia, 1990; Hogg et al., 1966):

$$V_{EDL} = \pi r_{NP} \varepsilon_0 \varepsilon_r \left\{ 2\phi_1\phi_2 \ln\left[\frac{1+\exp(-\kappa h)}{1-\exp(-\kappa h)}\right] + (\phi_1^2+\phi_2^2)\ln\left[1-\exp(-2\kappa h)\right] \right\} \tag{S3}$$

where ε_0 is the vacuum permittivity (8.85×10^{-12} C^2/Jm), ε_r is the relative dielectric permittivity of water (78.4), ϕ_1 denotes the measured ζ-potential of the PS-NPs; ϕ_2 corresponds to the ζ-potential of quartz sand. These values were obtained by Tufenkji's method (Tufenkji and Elimelech, 2004). The Debye reciprocal length κ could be calculated as (Russel et al., 1989):

$$\kappa = \sqrt{\frac{2N_A e^2 I}{\varepsilon_r \varepsilon_0 K_B T}} \tag{S4}$$

where N_A is the Avogadro number (6.02×10^{23} mol^{-1}), e is the electron charge (-1.60×10^{-19} C), I is the ionic strength of the background electrolyte, K_B is Boltzmann constant (1.38×10^{23} J/K), and T is Kelvin temperature (298 K).

Using equations S1 - S4, the interaction energy curves between PS-NPs and quartz sand could be calculated under various water chemistry conditions.

Table S1. Calculated the height of the energy barriers (Φ_{max}), secondary energy minimum (Φ_{sec}), and the respective separation distances of particle–collector DLVO interaction energy profiles

Minerals	θ	Background solution		Φ_{max}		Φ_{sec}	
		IS	pH	height (K_BT)	distance (nm)	depth (K_BT)	distance (nm)
GQS	0.05	10mM NaCl	4.0	-	-	-	-
	0.25	10mM NaCl	4.0	-	-	-	-
	0.10	10mM NaCl	4.0	-	-	-	-
	0.10	10mM NaCl+0.1mM propanoic acid	4.0	-	-	-	-
	0.10	10mM NaCl+0.1mM tartaric acid	4.0	-	-	-	-
	0.10	10mM NaCl	7.0	5.30	3.1	-0.43	17
	0.10	10mM NaCl+0.1mM propanoic acid	7.0	9.83	2.4	-0.26	19
	0.10	10mM NaCl+0.1mM tartaric acid	7.0	32.63	1.6	-0.15	24
	0.10	1mM NaCl	4.0	8.34	5.2	-0.02	85
	0.10	1mM NaCl+0.1mM propanoic acid	4.0	11.35	4.4	-0.02	85
	0.10	1mM NaCl+0.1mM tartaric acid	4.0	19.09	3.6	-0.01	85
	0.10	1mM $CaCl_2$	4.0	6.34	6.5	-0.03	75
	0.10	1mM $CaCl_2$+0.1mM propanoic acid	4.0	4.82	6.5	-0.02	75
	0.10	1mM $CaCl_2$+0.1mM tartaric acid	4.0	23.21	3.4	-0.02	75
	0.10	1mM $BaCl_2$	4.0	3.65	8.0	-0.05	70
	0.10	1mM $BaCl_2$+0.1mM propanoic acid	4.0	5.07	7.0	-0.04	70
	0.10	1mM $BaCl_2$+0.1mM tartaric acid	4.0	8.42	5.6	-0.03	70

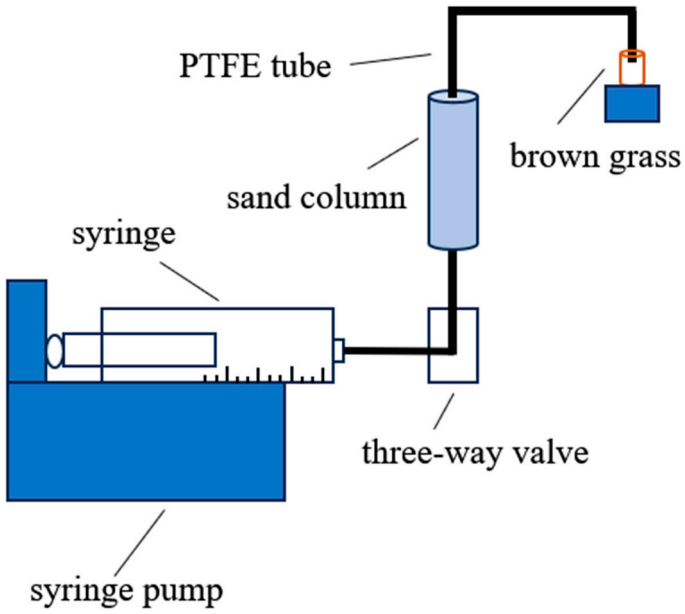


Figure S1. Experimental setup.

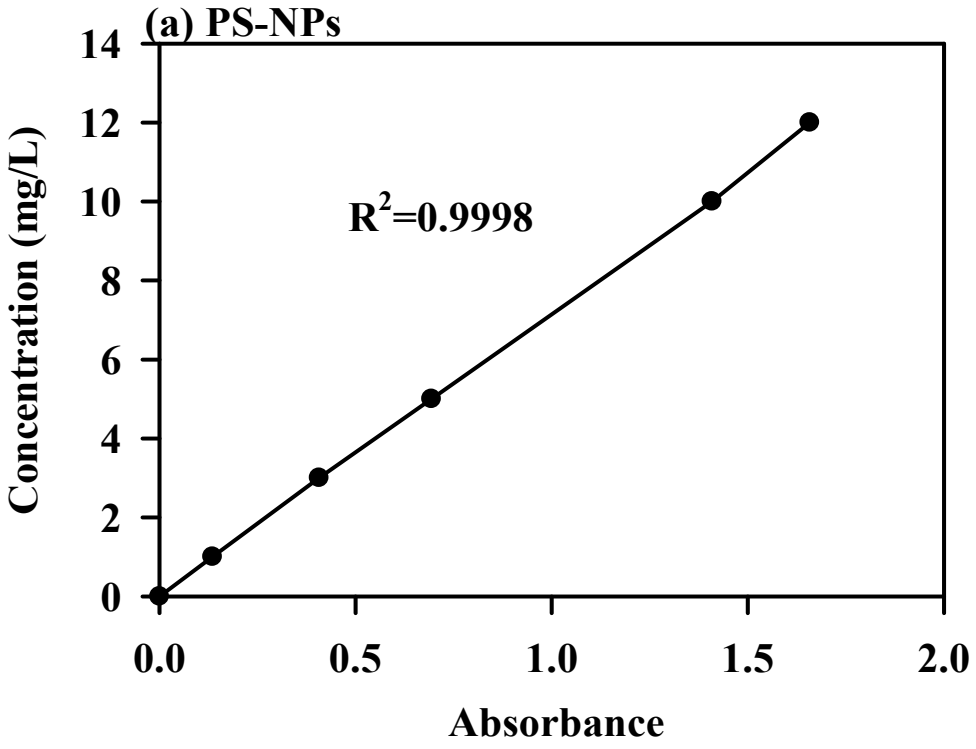


Figure S2. Calibration curve as absorbance at the wavelength of 220 nm vs. concentration of PS-NPs in suspension.

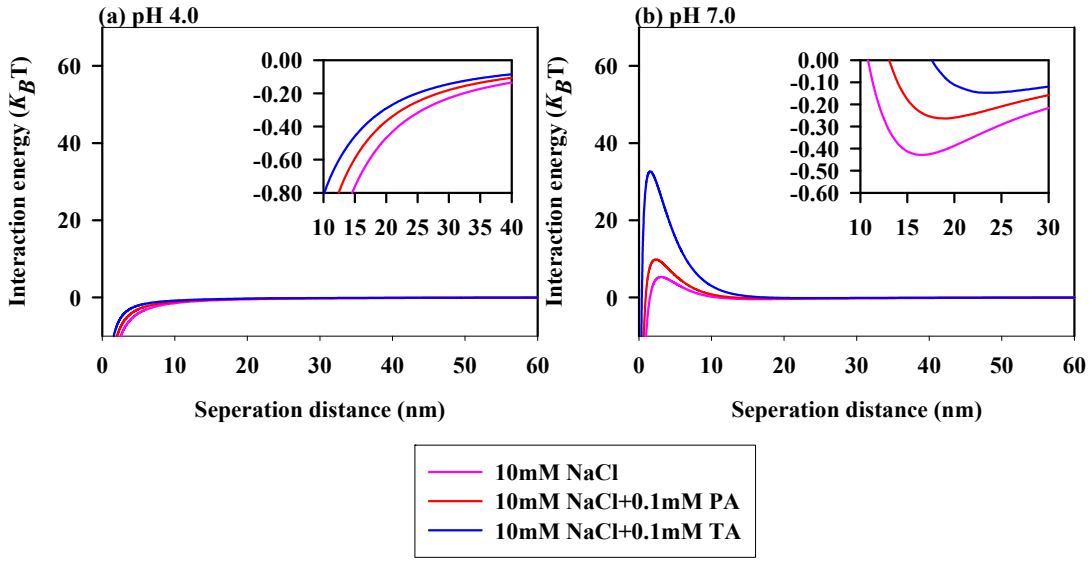


Figure S3. Calculated DLVO interaction energy profiles under LMWOAs (PA, and TA) at different pH (at a fixed ionic strength, 10 mM NaCl): (a) pH 4.0; and (b) pH 7.0. The insets are plotted on a smaller y-axis scale to highlight the secondary energy minimum.

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