Supporting materials

Table S1 Physicochemical characteristics of resins used in this study

Properties	S1	S2	S3	W1	W2	W3	C1	C2	C3	C4	C5	C6
Type	strong acid cation resin	macroporous strong acid cation resin	macroporous strong acid cation resin	macroporous weak acid cation resin	macroporous weak acid cation resin	macroporous weak acid cation resin	chelating resin	chelating resin	chelating resin	chelating resin	chelating resin	chelating resin
Ionic form	Na	Na	Na	H	H	H	free base	Na	Na		Na	Na
Polymer structure	styrene	styrene-diethylene benzene copolymer	styrene-diethylene benzene copolymer	acrylic acid copolymer	acrylic acid copolymer	acrylic acid copolymer	macroporous polyacrylic crosslinked with divinylbenzene	macroporous cinnamene styrene and diethenoid benzene copolymer	macroporous crosslinked polymer		styrene-diethylene benzene copolymer	styrene
Functional groups	sulfonic group	sulfonic group	sulfonic group	carboxylic acid group	carboxylic acid group	carboxylic acid group	Polyamine	imine diacetoxyl	aminophosphonic	imine diacetoxyl	imine diacetoxyl	aminophosphonic
Particle size (mm)	0.45–1.25	0.315–1.25	0.60–1.18	0.4–1.2	0.315–1.25	0.315–1.25		0.45–1.25	0.60–0.85		0.315–1.25	0.315–1.25
Moisture retention (%)	45–50		45–55	45–55	45–52	45–52	45–55	55–65	60–68	58–62	52–62	50–60
Mass exchange capacity (mmol/L)	≥ 4.50	≥ 4.35	≥ 4.35	≥ 11	≥ 10.8		2.70eq/L					Chelated calcium ≥ 1.45

Volume exchange capacity (mmol/L)	≥ 1.90	≥ 1.80	≥ 1.80		≥ 4.40	≥ 4.5		≥ 2.00		2.4		Chelated calcium ≥ 0.50
Wet density (g/mL)	0.77–0.87	0.75–0.85	0.77–0.85	0.72–0.82	0.74–0.80	0.72–0.80		0.70–0.80		0.70–0.80	0.70–0.80	
Wet true density (g/mL)	1.25–1.28	1.25–1.28	1.25–1.28	1.14–1.22	1.14–1.20	1.14–1.20	1.10	1.15–1.20	1.13	1.10–1.20	1.10–1.20	1.15–1.25
Reversible swelling				> 50	≤ 75	50			> 45			
pH range	1–14				5–14	4–14	0–10		0–14		1.5–14	6–11

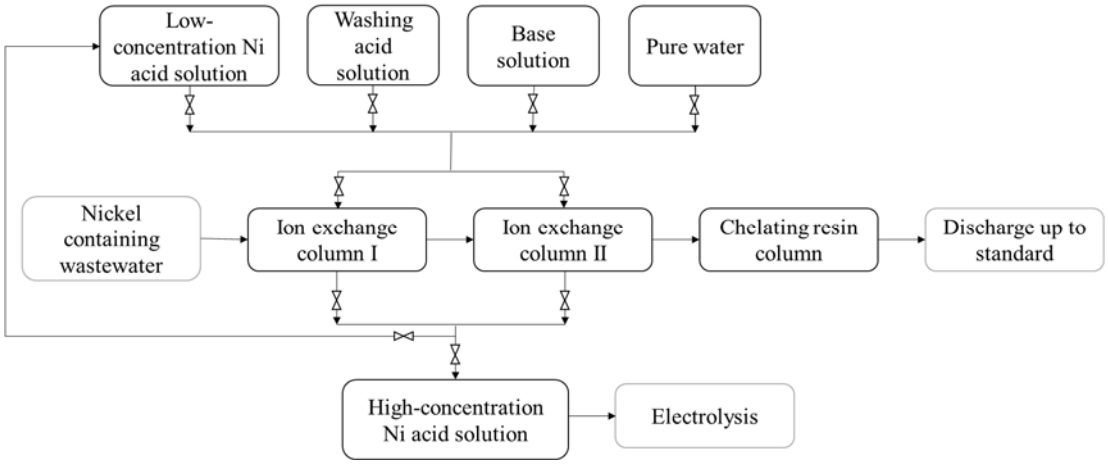

Fig. S1 Process flow diagram for the regeneration of spent resins

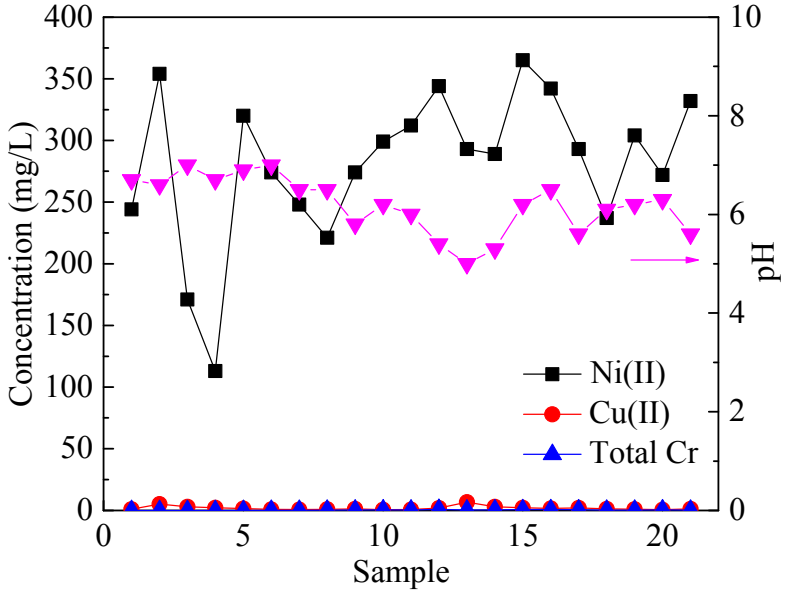

Fig. S2 Metal concentrations and pH values of nickel-containing wastewater during three months