sustainability

MDPI

Supplementary Materials

Removal of Base Metals from Mine Tailings in Chloride- and Seawater-Based Media Followed by Solvent Extraction

Table S1. Composition of artificial seawater (ATSM D1141 – 98 (2003))

Compound	Concentration (g/L)
NaCl	24.53
$MgCl_2$	5.20
Na_2SO_4	4.09
$CaCl_2$	1.16
KCl	0.695
$NaHCO_3$	0.201
KBr	0.101
H_3BO_3	0.027
$SrCl_2$	0.025
NaF	0.003

Table S2. Experimental parameters and Cu leaching results of DoE

Exp	NaCl (g/L)	HCl (mol/L)	Temp. (°C)	$Cu_{LE\ (\%)}$				
				0.5 h	**1 h**	**2 h**	**3 h**	**4 h**
1	10	0.1	45	10.1	10.5	11.3	11.9	11.7
2	60	0.1	45	9.5	10.2	10.7	11.4	11.6
3	10	1.0	45	8.1	8.2	9.1	9.7	10.1
4	60	1.0	45	7.8	8.6	9.5	10.3	10.8
5	10	0.5	20	6.3	6.4	6.5	6.7	6.8
6	60	0.5	20	6.1	6.3	6.6	6.7	6.9
7	10	0.5	70	12.0	16.5	23.7	28.7	32.4
8	60	0.5	70	12.1	15.9	21.6	25.7	29.2
9	35	0.1	20	6.3	6.4	6.2	6.3	6.5
10	35	1.0	20	6.6	6.9	7.0	7.2	7.4
11	35	0.1	70	5.2	7.7	9.2	10.8	11.3
12	35	1.0	70	13.1	17.2	23.8	27.7	30.1
13	35	0.5	45	7.6	8.2	9.3	10.0	10.6
14	35	0.5	45	7.2	7.7	8.9	9.3	9.6
15	35	0.5	45	7.4	8.1	8.9	9.6	10.0

Table S3. Experimental parameters and Zn leaching results of DoE

Exp	NaCl (g/L)	HCl (mol/L)	Temp. (°C)	$Zn_{LE\ (\%)}$				
				0.5 h	**1 h**	**2 h**	**3 h**	**4 h**
1	10	0.1	45	11.4	12.6	14.6	15.9	15.9
2	60	0.1	45	10.7	12.5	14.1	15.5	15.9
3	10	1.0	45	13.6	15.2	18.1	20.4	22.4
4	60	1.0	45	12.9	15.0	17.6	20.0	21.8
5	10	0.5	20	8.3	9.4	10.8	11.7	12.4
6	60	0.5	20	7.5	8.5	9.8	10.5	11.0
7	10	0.5	70	15.0	17.4	22.6	27.3	31.5
8	60	0.5	70	15.8	17.7	22.1	26.1	30.2
9	35	0.1	20	6.2	6.3	6.9	7.5	7.8
10	35	1.0	20	8.3	9.5	10.7	11.4	12.0
11	35	0.1	70	13.9	15.3	17.2	18.9	19.3
12	35	1.0	70	17.1	19.4	25.6	31.1	36.5
13	35	0.5	45	12.2	13.8	16.2	18.3	20.1
14	35	0.5	45	12.6	14.0	17.7	18.8	20.3
15	35	0.5	45	12.0	13.7	16.1	18.0	19.7

Table S4. Experimental parameters and Pb leaching results of DoE

Exp	NaCl (g/L)	HCl (mol/L)	Temp. (°C)	$Pb_{LE(\%)}$				
				0.5 h	1 h	2 h	3 h	4 h
1	10	0.1	45	33.2	21.6	20.7	19.8	17.6
2	60	0.1	45	58.9	64.9	68.5	70.2	67.3
3	10	1.0	45	73.1	75.5	78.2	79.8	81.1
4	60	1.0	45	69.2	72.6	74.3	76.6	77.4
5	10	0.5	20	68.9	70.8	73.4	74.9	76.0
6	60	0.5	20	64.6	67.2	70.2	71.8	72.7
7	10	0.5	70	76.6	79.5	82.5	84.8	87.2
8	60	0.5	70	73.3	75.3	78.3	80.0	82.2
9	35	0.1	20	52.1	53.4	56.8	58.5	59.7
10	35	1.0	20	67.1	69.8	72.2	73.2	73.9
11	35	0.1	70	66.1	67.0	68.5	71.0	68.8
12	35	1.0	70	74.8	76.2	79.7	81.3	83.1
13	35	0.5	45	70.1	72.8	75.4	77.1	78.9
14	35	0.5	45	71.4	74.4	77.9	79.7	80.0
15	35	0.5	45	70.0	74.3	76.4	78.0	79.0

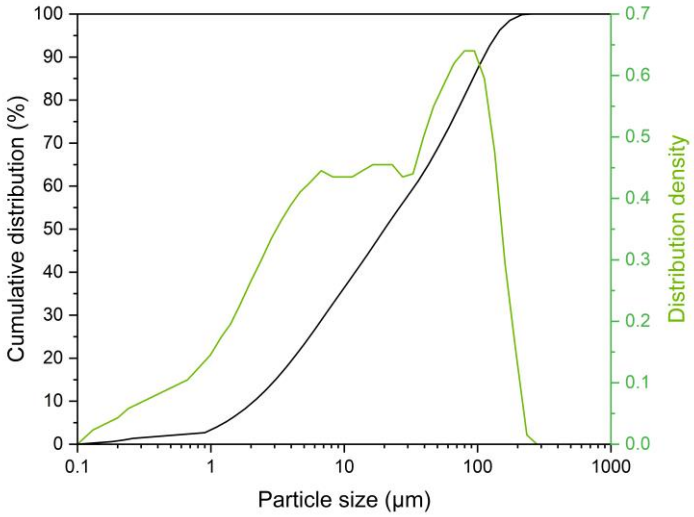


Figure S1. Particle size distribution of the Cu-Zn tailings used in the experiments (d_{10} = 2.16 μm, d_{50} = 21.39 μm, d_{90} = 115.86 μm). Adapted from [17].

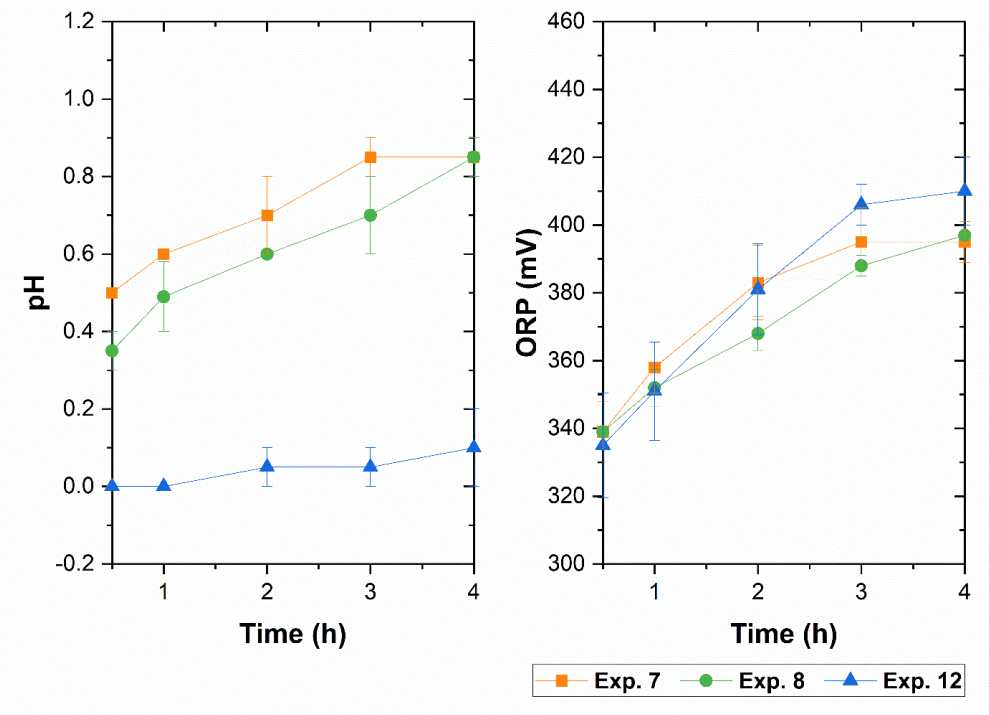


Figure S2. pH and ORP measured during the DoE experiment

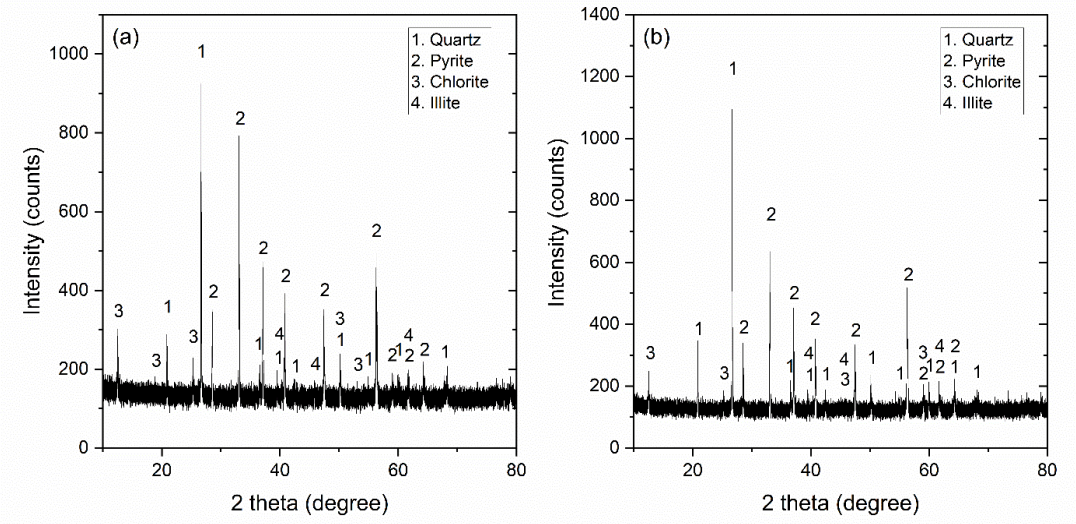


Figure S3. XRD pattern of the mine tailings sample leached with (a) deionized water and (b) artificial seawater (quartz: SiO_2; pyrite: FeS_2; chlorite: $A_{5\text{-}6}T_4Z_{18}$, where A = Al, Fe^{2+}, Fe^{3+}, Li, Mg, Mn, or Ni, while T = Al, Fe^{3+}, Si, or a combination of them, and Z = O and/or OH; illite: $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$]).