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APPENDICES

APPENDIX A: CHEMICAL ANALYSIS OF TAILINGS

Table A.1 Chemical analysis of tailing solid samples and top soil at the Akara Mine

No.	Type	Concentration (mg g^{-1})																						
		Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg*	K	Li	Mg	Mn	Na	Ni	Pb	Sr	Tl	Zn
1		ND	10.88	ND	0.11	0.14	ND	44.08	ND	ND	ND	0.07	20.48	ND	0.14	2.61	ND	5.00	2.54	ND	0.06	0.03	0.04	ND	0.20
2		ND	10.71	ND	0.10	0.14	ND	45.41	ND	ND	ND	0.07	20.28	ND	0.16	2.56	ND	4.91	2.58	ND	0.08	0.03	0.04	ND	0.14
3		ND	9.09	ND	0.09	0.14	ND	51.76	ND	ND	ND	0.06	18.94	ND	0.14	2.49	ND	4.66	2.30	ND	0.05	0.02	0.05	ND	0.09
4		ND	12.52	ND	0.10	0.20	ND	50.51	ND	ND	ND	0.07	19.08	ND	0.23	2.61	ND	5.13	2.69	ND	0.07	0.03	0.04	ND	0.12
5		ND	12.73	ND	0.11	0.23	ND	48.68	ND	ND	ND	0.08	21.51	ND	0.12	2.54	ND	5.23	2.69	0.48	0.05	0.03	0.05	ND	0.12
6		ND	10.65	ND	0.09	0.29	ND	49.86	ND	ND	ND	0.07	19.00	ND	0.28	2.47	ND	4.94	2.46	ND	0.06	0.04	0.05	ND	0.15
7		ND	9.44	ND	0.07	0.28	ND	42.60	ND	ND	ND	0.06	16.76	ND	0.26	2.37	ND	4.71	2.14	ND	0.06	0.05	0.05	ND	0.18
8		ND	9.43	ND	0.12	0.10	ND	44.44	ND	ND	ND	0.07	19.98	ND	1.72	2.47	ND	4.74	2.41	ND	0.07	0.03	0.03	ND	0.12
9		ND	8.27	ND	0.13	0.09	ND	40.07	ND	ND	ND	0.09	20.86	ND	0.36	2.42	ND	4.42	2.31	ND	0.08	0.04	0.03	ND	0.21
10		ND	13.23	ND	0.17	0.17	ND	44.68	ND	ND	ND	0.08	21.05	ND	0.16	2.79	ND	5.08	2.53	ND	0.09	0.04	0.04	ND	0.21
11	Tailings	ND	7.28	ND	0.04	0.05	ND	27.23	ND	ND	ND	0.02	11.41	ND	0.17	2.58	ND	3.86	1.67	0.33	0.07	0.00	0.02	ND	0.05
12		ND	13.52	ND	0.09	0.17	ND	46.35	ND	ND	ND	0.07	20.06	ND	0.19	2.44	ND	5.24	2.84	ND	0.08	0.03	0.04	ND	0.16
13		ND	11.32	ND	0.10	0.12	ND	40.76	ND	ND	ND	0.09	20.83	ND	0.19	2.42	ND	4.97	2.84	ND	0.08	0.05	0.04	ND	0.22
14		ND	10.68	ND	0.11	0.10	ND	40.08	ND	ND	ND	0.07	18.62	ND	0.15	2.43	ND	4.85	2.66	ND	0.07	0.02	0.03	ND	0.12
15		ND	11.36	ND	0.10	0.13	ND	43.40	ND	ND	ND	0.08	20.21	ND	0.40	2.50	ND	4.76	2.67	ND	0.07	0.04	0.03	ND	0.18
16		ND	8.97	ND	0.13	0.14	ND	41.97	ND	ND	ND	0.08	18.92	ND	1.73	2.52	ND	4.47	2.46	ND	0.05	0.03	0.03	ND	0.15
17		ND	10.82	ND	0.10	0.09	ND	24.21	ND	ND	ND	0.09	22.09	ND	0.25	2.75	ND	5.16	2.36	ND	0.08	0.13	0.02	ND	0.28
18		ND	10.39	ND	0.12	0.04	ND	28.60	ND	ND	ND	0.09	22.90	ND	0.94	2.61	ND	5.36	2.39	ND	0.11	0.07	0.02	ND	0.25
19		ND	13.67	ND	0.09	0.18	ND	45.80	ND	ND	ND	0.07	18.76	ND	0.26	2.71	ND	5.30	2.75	ND	0.06	0.04	0.04	ND	0.16
20		ND	12.70	ND	0.10	0.17	ND	42.88	ND	ND	ND	0.08	21.43	ND	0.17	2.53	ND	5.25	2.65	ND	0.06	0.05	0.04	ND	0.23
21		ND	9.49	ND	0.07	0.15	ND	47.11	ND	ND	ND	0.06	18.08	ND	0.34	2.40	ND	4.81	2.39	ND	0.09	0.04	0.04	ND	0.15
22		ND	10.99	ND	0.11	0.11	ND	29.10	ND	ND	ND	0.09	22.37	ND	0.46	2.56	ND	4.41	2.37	ND	0.06	0.06	0.02	ND	0.24
1		ND	7.87	ND	0.17	0.01	ND	0.59	ND	ND	ND	0.02	28.04	ND	0.38	0.67	ND	0.38	0.11	ND	ND	ND	ND	ND	ND
2	top soil	ND	7.73	ND	0.06	0.04	ND	1.21	ND	ND	ND	0.06	19.12	ND	0.12	1.26	ND	1.53	0.13	ND	ND	ND	0.01	ND	0.04
3		ND	5.98	ND	0.09	0.04	ND	1.29	ND	ND	ND	0.05	19.04	ND	0.06	1.28	ND	1.53	0.14	ND	ND	ND	0.01	ND	0.04
4		ND	8.48	ND	0.13	0.09	ND	1.88	ND	ND	ND	0.05	24.19	ND	0.04	1.86	ND	2.01	0.18	ND	ND	ND	0.02	ND	0.09
5		ND	6.35	ND	0.02	0.04	ND	3.47	ND	ND	ND	ND	4.83	ND	0.03	2.15	ND	1.94	0.03	ND	ND	ND	0.03	ND	ND

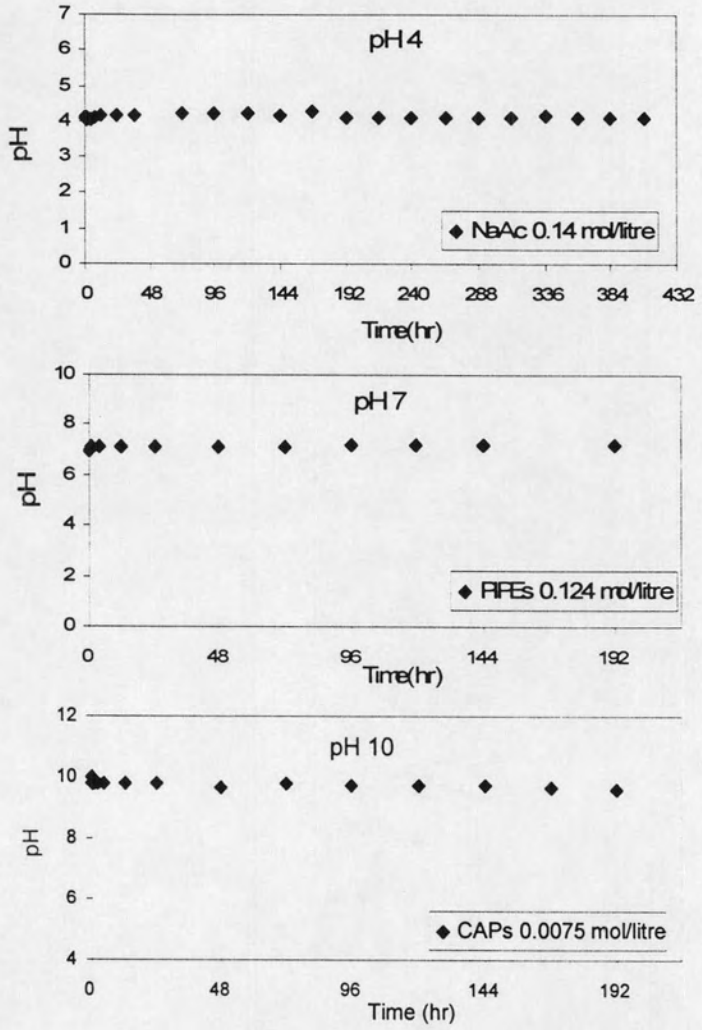

Figure A.1 3 pH conditions under batch desorption experiments.

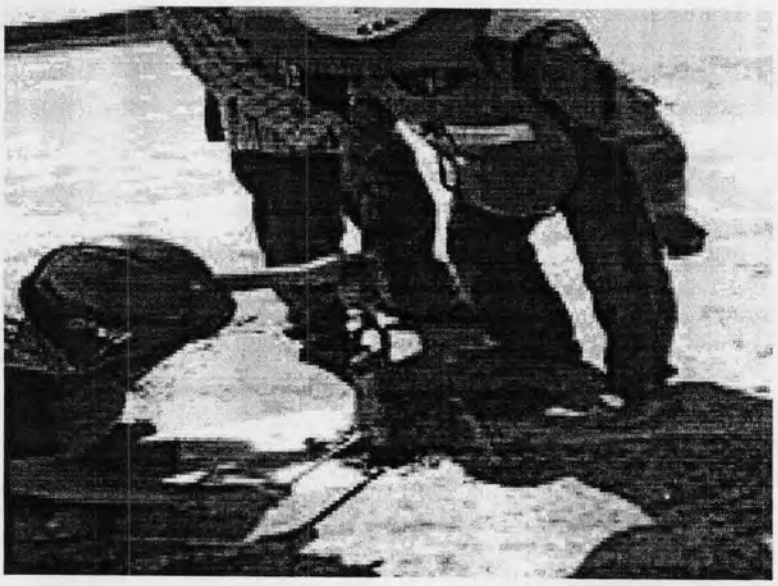

Figure A.2 Tailings samplings

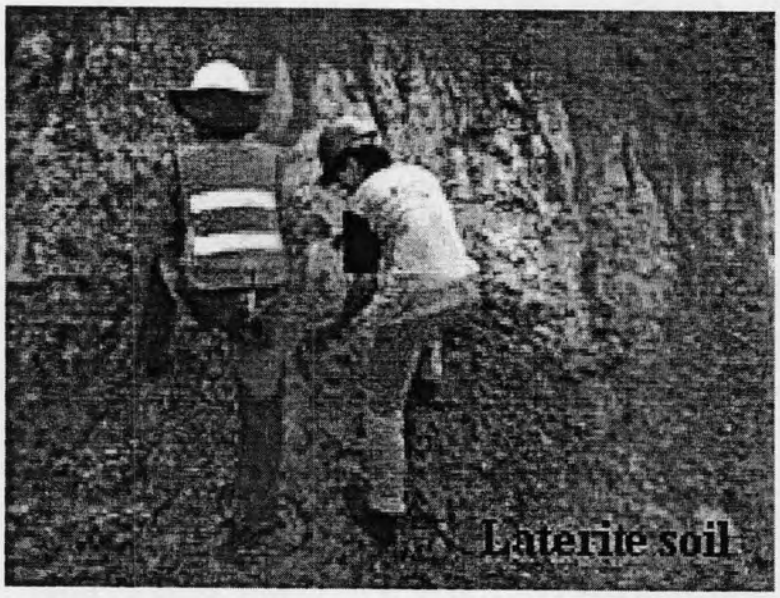

Figure A.3 Lateritic soil samplings

APPENDIX B: COLUMN EXPERIMENT DATA FOR SINGLE METAL SYSTEMS

Table B.1 Observed, predicted and simulated breakthrough curves of Lead (Pb) transport through lateritic soil under pH 4 with initial concentration 5.28 mmol L^{-1}

Sample #	Pore volume	Observed data Pb Conc.(mM)	C/C0	Predicted Langmuir C/C0	Linear C/C0	Fitted Langmuir C/C0	TSM C/C0
1	0.33	0.00	0.00	0.00	0.00	0.00	0.00
2	2.86	0.00	0.00	0.00	0.00	0.00	0.00
3	5.15	0.00	0.00	0.00	0.01	0.00	0.00
4	7.69	4.77	0.01	0.00	0.03	0.00	0.00
5	10.44	4.93	0.01	0.05	0.10	0.00	0.00
6	11.86	6.65	0.01	0.23	0.14	0.00	0.00
7	16.03	33.02	0.03	0.43	0.31	0.00	0.00
8	18.81	89.81	0.09	0.63	0.42	0.00	0.00
9	21.50	133.95	0.14	0.78	0.52	0.00	0.02
10	24.24	215.70	0.23	0.87	0.61	0.00	0.16
11	26.97	316.60	0.33	0.93	0.69	0.00	0.42
12	29.72	424.65	0.45	0.96	0.75	0.00	0.54
13	32.48	512.50	0.54	0.98	0.80	0.47	0.62
14	35.28	587.50	0.62	0.99	0.85	0.99	0.68
15	38.04	651.50	0.69	0.99	0.88	1.00	0.74
16	40.79	703.50	0.74	1.00	0.91	1.00	0.78
17	43.52	798.50	0.84	1.00	0.93	1.00	0.82
18	46.25	828.50	0.87	1.00	0.94	1.00	0.85
19	49.00	846.00	0.89	1.00	0.95	1.00	0.87
20	51.80	879.50	0.93	1.00	0.96	1.00	0.89
21	53.46	886.50	0.94	1.00	0.97	1.00	0.90
22	55.95	896.00	0.95	1.00	0.98	1.00	0.92
23	58.73	907.50	0.96	1.00	0.98	1.00	0.93
24	61.49	923.50	0.98	1.00	0.99	1.00	0.94
25	64.29	933.50	0.99	1.00	0.99	1.00	0.95
26	67.06	946.50	1.00	1.00	0.99	1.00	0.96
27	69.86	919.50	0.97	1.00	0.99	1.00	0.97
28	72.66	943.50	1.00	1.00	0.99	1.00	0.97
29	75.46	956.00	1.01	1.00	1.00	1.00	0.98
30	78.22	946.00	1.00	1.00	1.00	1.00	0.98
31	80.96	964.50	1.02	1.00	1.00	1.00	0.98
32	83.73	991.00	1.05	1.00	1.00	0.99	0.98
33	84.26	999.00	1.06	1.00	1.00	0.90	0.90
34	84.54	978.00	1.03	1.00	1.00	0.83	0.84
35	84.81	922.00	0.97	0.99	1.00	0.77	0.78
36	85.07	778.50	0.82	0.99	1.00	0.71	0.73
37	85.33	673.50	0.71	0.98	1.00	0.66	0.68
38	85.85	495.50	0.52	0.86	1.00	0.58	0.61
39	86.38	409.40	0.43	0.71	1.00	0.52	0.55
40	88.97	295.90	0.31	0.60	0.98	0.36	0.40
41	91.81	245.85	0.26	0.52	0.93	0.29	0.33
42	94.13	205.95	0.22	0.42	0.85	0.25	0.30
43	96.22	180.85	0.19	0.36	0.77	0.22	0.28

Table B.2 Observed, predicted and simulated breakthrough curves of Zinc (Zn) transport through lateritic soil under pH 4 with initial concentration 4.67 mmol/L

Sample #	Pore volume	Observed data Zn Conc.(mM)	C/C0	Predicted Langmuir C/C0	Linear C/C0	Fitted Langmuir C/C0	TSM C/C0
1	0.00	0.00	0.00	0.00	0.02	0.00	0.00
2	3.11	0.08	0.02	0.00	0.03	0.00	0.00
3	4.06	0.09	0.02	0.00	0.07	0.00	0.00
4	7.45	0.43	0.09	0.02	0.33	0.00	0.00
5	10.88	1.24	0.27	0.16	0.58	0.00	0.24
6	13.17	1.99	0.43	0.34	0.71	0.42	0.48
7	16.90	2.52	0.54	0.66	0.83	0.99	0.61
8	20.06	3.01	0.64	0.83	0.89	1.00	0.68
9	23.84	3.50	0.75	0.93	0.93	1.00	0.73
10	27.01	3.76	0.80	0.97	0.95	1.00	0.77
11	33.90	3.85	0.82	0.99	0.96	1.00	0.84
12	38.51	4.37	0.94	1.00	0.96	1.00	0.87
13	41.67	4.29	0.92	1.00	0.96	1.00	0.89
14	47.72	4.33	0.93	1.00	0.97	1.00	0.92
15	51.28	4.28	0.92	1.00	0.97	1.00	0.93
16	54.34	4.42	0.95	1.00	0.97	1.00	0.94
17	58.00	4.46	0.96	1.00	0.97	1.00	0.95
18	61.04	4.40	0.94	1.00	0.97	1.00	0.96
19	64.54	4.39	0.94	1.00	0.97	1.00	0.97
20	67.45	4.58	0.98	1.00	0.97	1.00	0.97
21	73.79	4.43	0.95	1.00	0.97	1.00	0.98
22	78.00	4.38	0.94	1.00	0.97	1.00	0.98
23	79.06	4.31	0.92	1.00	0.96	0.94	0.92
24	79.58	4.29	0.92	0.99	0.96	0.83	0.81
25	80.10	4.11	0.88	0.98	0.95	0.73	0.71
26	80.62	3.07	0.66	0.96	0.94	0.65	0.63
27	81.13	2.30	0.49	0.94	0.92	0.58	0.57
28	81.89	2.07	0.44	0.89	0.88	0.51	0.50
29	82.66	1.90	0.41	0.84	0.83	0.45	0.45
30	83.17	1.83	0.39	0.81	0.79	0.42	0.42
31	83.93	1.69	0.36	0.76	0.72	0.38	0.39
32	86.38	1.32	0.28	0.60	0.49	0.30	0.32
33	88.70	1.06	0.23	0.47	0.31	0.24	0.28
34	91.01	0.93	0.20	0.37	0.19	0.21	0.26
35	93.25	0.80	0.17	0.30	0.11	0.18	0.24
36	95.45	0.71	0.15	0.24	0.07	0.16	0.22
37	97.58	0.64	0.14	0.20	0.04	0.14	0.20
38	99.62	0.61	0.13	0.16	0.02	0.13	0.19

Table B.3 Observed, predicted and simulated breakthrough curves of Nickel (Ni) transport through lateritic soil under pH 4 with initial concentration 5.06 mmol/L

Sample #	Pore volume	Observed data Ni Conc.(mM)	C/C0	Predicted Langmuir C/C0	Linear C/C0	Fitted Langmuir C/C0	TSM C/C0
1	0.28	0.00	0.00	0.00	0.01	0.00	0.00
2	0.55	0.05	0.01	0.00	0.03	0.00	0.00
3	0.83	0.25	0.05	0.00	0.12	0.00	0.01
4	1.11	0.45	0.09	0.00	0.15	0.00	0.01
5	1.39	0.58	0.11	0.00	0.22	0.00	0.04
6	1.66	0.78	0.15	0.00	0.25	0.00	0.06
7	1.94	1.22	0.24	0.00	0.43	0.00	0.24
8	2.22	1.99	0.39	0.00	0.68	0.01	0.50
9	2.50	2.36	0.47	0.00	0.77	0.50	0.58
10	2.77	3.38	0.67	0.00	0.89	0.99	0.71
11	3.05	4.11	0.81	0.00	0.95	1.00	0.79
12	3.33	4.61	0.91	0.00	0.97	1.00	0.85
13	3.61	4.58	0.91	0.00	0.99	1.00	0.90
14	3.88	4.76	0.94	0.00	0.99	1.00	0.93
15	4.16	4.80	0.95	0.00	1.00	1.00	0.96
16	4.44	4.95	0.98	0.00	1.00	1.00	0.97
17	4.71	4.96	0.98	0.00	1.00	1.00	0.98
18	4.99	4.92	0.97	0.00	1.00	1.00	0.98
19	5.27	4.98	0.98	0.00	1.00	1.00	0.99
20	5.55	5.07	1.00	0.00	1.00	1.00	0.99
21	5.82	4.72	0.93	0.00	1.00	1.00	0.99
22	6.10	4.90	0.97	0.00	1.00	0.91	0.80
23	6.38	4.10	0.81	0.01	0.99	0.68	0.60
24	6.66	2.57	0.51	0.01	0.98	0.58	0.52
25	6.93	2.12	0.42	0.01	0.95	0.51	0.47
26	7.21	1.59	0.31	0.02	0.87	0.44	0.41
27	7.49	0.88	0.17	0.02	0.54	0.30	0.32
28	7.76	0.62	0.12	0.03	0.28	0.23	0.27
29	8.04	0.48	0.10	0.04	0.14	0.19	0.24
30	8.32	0.56	0.11	0.05	0.07	0.16	0.21
31	8.60	0.44	0.09	0.07	0.03	0.14	0.18

Table B.4 Observed, predicted and simulated breakthrough curves of Mangnese (Mn) transport through lateritic soil under pH 4 with initial concentration 4.87 mmol/L

Sample #	Pore volume	Observed data Mn Conc.(mM)	C/C0	Predicted Langmuir C/C0	Linear C/C0	Fitted Langmuir C/C0	TSM C/C0
1	1.29	0.06	0.01	0.00	0.02	0.00	0.00
2	2.68	0.04	0.01	0.00	0.06	0.00	0.00
3	3.73	0.09	0.02	0.01	0.29	0.00	0.01
4	7.06	0.74	0.15	0.25	0.48	0.02	0.26
5	9.52	1.42	0.29	0.71	0.66	0.51	0.49
6	12.41	1.90	0.39	0.94	0.83	0.97	0.62
7	16.36	2.56	0.53	0.99	0.88	0.99	0.67
8	18.59	2.70	0.55	1.00	0.94	1.00	0.75
9	22.53	3.21	0.66	1.00	0.96	1.00	0.79
10	25.03	3.38	0.70	1.00	0.98	1.00	0.82
11	27.93	4.15	0.85	1.00	0.99	1.00	0.86
12	31.08	4.47	0.92	1.00	0.99	1.00	0.88
13	34.25	4.53	0.93	1.00	1.00	1.00	0.93
14	37.57	4.48	0.92	1.00	1.00	1.00	0.94
15	41.26	4.70	0.97	1.00	1.00	1.00	0.95
16	44.17	4.75	0.98	1.00	1.00	1.00	0.96
17	46.73	4.80	0.99	1.00	1.00	1.00	0.97
18	51.20	4.92	1.01	1.00	1.00	1.00	0.95
19	52.46	4.93	1.01	1.00	1.00	0.94	0.72
20	57.14	4.90	1.01	1.00	0.99	0.84	0.55
21	57.89	5.16	1.06	0.97	0.98	0.74	0.45
22	58.67	3.53	0.73	0.89	0.96	0.66	0.39
23	59.44	2.12	0.43	0.80	0.70	0.41	0.28
24	60.21	1.62	0.33	0.71	0.53	0.34	0.25
25	63.26	1.07	0.22	0.40	0.31	0.27	0.22
26	65.35	0.85	0.18	0.30	0.19	0.22	0.20
27	68.64	0.67	0.14	0.21	0.11	0.18	0.19
28	71.19	0.57	0.12	0.15	0.06	0.16	0.17
29	74.18	0.49	0.10	0.11	0.03	0.13	0.16
30	76.93	0.44	0.09	0.08	0.02	0.12	0.15
31	79.36	0.41	0.08	0.06	0.00	0.00	0.00
32	81.31	0.37	0.08	0.04	0.00	0.00	0.00

Table B.5 Observed and simulated breakthrough curves of Lead (Pb) transport through lateritic soil under pH 5 with initial concentration 5.05 mol/L

Sample #	Pore volume	Observed data Pb Conc.(mM)	C/C0	Fitted Linear C/C0	Fitted Langmuir C/C0	Fitted TSM C/C0
1	1.76	0.00	0.00	0.00	0.00	0.00
2	5.24	0.00	0.00	0.00	0.00	0.00
3	7.84	0.00	0.00	0.01	0.00	0.00
4	10.38	0.00	0.00	0.04	0.00	0.00
5	11.30	0.00	0.00	0.10	0.00	0.00
6	13.85	0.07	0.01	0.16	0.00	0.00
7	16.36	0.45	0.09	0.24	0.00	0.00
8	18.88	0.98	0.19	0.31	0.00	0.03
9	21.42	1.07	0.21	0.39	0.00	0.20
10	23.96	1.47	0.29	0.46	0.00	0.36
11	25.21	1.83	0.36	0.49	0.00	0.40
12	27.73	1.97	0.39	0.55	0.00	0.47
13	30.25	2.21	0.44	0.61	0.00	0.52
14	32.76	2.54	0.50	0.65	0.62	0.57
15	35.27	2.92	0.58	0.70	1.00	0.61
16	37.75	2.94	0.58	0.73	1.00	0.65
17	40.25	3.25	0.64	0.77	1.00	0.69
18	42.75	3.38	0.67	0.80	1.00	0.72
19	45.25	3.71	0.73	0.82	1.00	0.75
20	47.75	3.90	0.77	0.84	1.00	0.77
21	48.98	3.94	0.78	0.85	1.00	0.78
22	51.39	4.05	0.80	0.87	1.00	0.81
23	53.86	4.40	0.87	0.89	1.00	0.83
24	56.36	4.09	0.81	0.90	1.00	0.84
25	58.87	4.44	0.88	0.91	1.00	0.86
26	61.32	4.66	0.92	0.92	1.00	0.87
27	63.79	4.52	0.89	0.93	1.00	0.89
28	66.30	4.54	0.90	0.94	1.00	0.90
29	68.79	4.73	0.94	0.94	1.00	0.91
30	72.58	4.86	0.96	0.95	1.00	0.92
31	75.10	4.89	0.97	0.95	1.00	0.93
32	77.37	4.73	0.94	0.96	1.00	0.94
33	80.17	4.91	0.97	0.96	1.00	0.94
34	82.72	4.89	0.97	0.96	1.00	0.95
35	85.24	4.90	0.97	0.97	1.00	0.95
36	87.78	5.04	1.00	0.97	1.00	0.96
37	90.32	5.09	1.01	0.97	1.00	0.96
38	92.82	5.58	1.11	0.97	1.00	0.97
39	93.33	5.59	1.11	0.97	1.00	0.97
40	93.84	5.61	1.11	0.97	1.00	0.97
41	94.10	5.60	1.11	0.97	1.00	0.97
42	94.36	5.42	1.07	0.97	0.99	0.96
43	94.89	4.60	0.91	0.97	0.85	0.84
44	95.41	3.72	0.74	0.97	0.68	0.69
45	95.93	3.07	0.61	0.97	0.57	0.58
46	96.71	2.55	0.50	0.96	0.47	0.48
47	98.02	2.13	0.42	0.95	0.37	0.39
48	99.31	1.82	0.36	0.94	0.31	0.34

Table B.5 Observed and simulated breakthrough curves of Lead (Pb) transport through lateritic soil under pH 5 with initial concentration 5.05 mol/L (Continued)

49	101.94	1.40	0.28	0.89	0.25	0.28
50	104.44	1.12	0.22	0.82	0.21	0.25
51	107.25	0.97	0.19	0.74	0.18	0.23
52	109.55	0.87	0.17	0.67	0.17	0.22
53	112.11	0.79	0.16	0.60	0.15	0.21
54	114.67	0.75	0.15	0.53	0.14	0.20
55	117.23	0.72	0.14	0.47	0.13	0.19
56	121.08	0.69	0.14	0.38	0.12	0.18
57	123.61	0.68	0.13	0.33	0.11	0.18
58	126.16	0.68	0.13	0.29	0.11	0.17
59	128.68	0.65	0.13	0.25	0.10	0.16
60	131.20	0.64	0.13	0.22	0.10	0.16
61	133.73	0.64	0.13	0.19	0.10	0.15
62	136.25	0.62	0.12	0.16	0.09	0.15
63	138.78	0.59	0.12	0.14	0.09	0.15
64	141.27	0.60	0.12	0.12	0.09	0.14
65	144.96	0.55	0.11	0.10	0.08	0.14
66	147.40	0.56	0.11	0.08	0.08	0.13
67	149.84	0.56	0.11	0.07	0.08	0.13
68	152.25	0.54	0.11	0.06	0.07	0.13
69	154.64	0.52	0.10	0.05	0.07	0.12
70	156.99	0.50	0.10	0.05	0.07	0.12
71	159.32	0.48	0.09	0.04	0.07	0.12
72	161.59	0.47	0.09	0.04	0.07	0.11
73	163.80	0.43	0.09	0.03	0.07	0.11
74	164.02	0.39	0.08	0.03	0.07	0.11
75	169.26	0.39	0.08	0.02	0.06	0.11
76	173.45	0.35	0.07	0.02	0.06	0.10
77	175.51	0.33	0.07	0.01	0.06	0.10

Table B.6 Observed and simulated breakthrough curves of Lead (Pb) transport through lateritic soil under pH 5 with initial concentration 5.01 mol/L (Duplicated Column)

Sample #	Pore volume	Observed data Pb Conc.(mM)	C/C0	Fitted Linear C/C0	Fitted Langmuir C/C0	Fitted TSM C/C0
1	0.00	0.00	0.00	0.00	0.00	0.00
2	3.24	0.00	0.00	0.00	0.00	0.00
3	10.08	0.00	0.00	0.03	0.00	0.00
4	17.62	0.00	0.00	0.23	0.00	0.00
5	20.16	0.07	0.01	0.33	0.00	0.00
6	23.22	0.29	0.06	0.44	0.00	0.00
7	27.39	0.94	0.19	0.59	0.00	0.14
8	31.26	1.64	0.33	0.70	0.34	0.51
9	36.58	2.63	0.53	0.81	1.00	0.62
10	40.73	3.20	0.64	0.87	1.00	0.68
11	43.26	3.67	0.73	0.90	1.00	0.71
12	49.56	4.04	0.81	0.95	1.00	0.78
13	51.68	4.24	0.85	0.96	1.00	0.80
14	59.74	4.55	0.91	0.98	1.00	0.86
15	64.22	4.75	0.95	0.99	1.00	0.89
16	69.25	4.75	0.95	0.99	1.00	0.91
17	72.56	4.73	0.94	1.00	1.00	0.93
18	76.11	4.69	0.94	1.00	1.00	0.94
19	81.70	4.80	0.96	1.00	1.00	0.95
20	85.68	4.92	0.98	1.00	1.00	0.96
21	89.48	4.78	0.96	1.00	1.00	0.96
22	95.71	4.77	0.95	1.00	1.00	0.97
23	97.58	4.76	0.95	1.00	1.00	0.98
24	98.64	4.71	0.94	1.00	0.96	0.93
25	99.17	4.65	0.93	1.00	0.87	0.83
26	99.68	4.62	0.92	1.00	0.77	0.72
27	100.20	3.92	0.78	1.00	0.69	0.64
28	100.72	2.97	0.59	1.00	0.63	0.58
29	101.23	2.53	0.51	1.00	0.57	0.53
30	101.74	2.31	0.46	1.00	0.53	0.49
31	102.26	2.16	0.43	1.00	0.50	0.46
32	103.58	1.80	0.36	1.00	0.43	0.40
33	104.90	1.47	0.29	1.00	0.38	0.36
34	107.54	1.01	0.20	0.98	0.32	0.31
35	110.15	0.80	0.16	0.93	0.28	0.28
36	112.80	0.70	0.14	0.86	0.25	0.26
37	115.40	0.59	0.12	0.76	0.22	0.24
38	119.32	0.72	0.14	0.50	0.18	0.21
39	121.89	0.66	0.13	0.41	0.17	0.20
40	124.44	0.65	0.13	0.33	0.16	0.19
41	127.00	0.65	0.13	0.05	0.12	0.15
42	129.58	0.66	0.13	0.02	0.10	0.14
43	132.12	0.68	0.13	0.02	0.10	0.14
44	134.60	0.67	0.13	0.01	0.10	0.13
45	137.11	0.65	0.13	0.01	0.09	0.13
46	139.56	0.71	0.14	0.01	0.09	0.12
47	142.99	0.66	0.13	0.00	0.09	0.12
48	145.39	0.60	0.12	0.00	0.09	0.12
49	147.75	0.63	0.13	0.00	0.00	0.00

Table B.6 Observed and simulated breakthrough curves of Lead (Pb) transport through lateritic soil under pH 5 with initial concentration 5.01 mol/L (Duplicated Column) (Continued)

50	150.05	0.62	0.12	0.00	0.00	0.00
51	152.32	0.54	0.11	0.00	0.00	0.00
52	154.52	0.48	0.10	0.00	0.00	0.00
53	156.63	0.44	0.09	0.00	0.00	0.00
54	158.69	0.40	0.08	0.00	0.00	0.00
55	160.62	0.33	0.07	0.00	0.00	0.00
56	162.74	0.30	0.06	0.00	0.00	0.00
57	164.66	0.26	0.05	0.00	0.00	0.00

Table B.7 Observed and simulated breakthrough curves of Zinc (Zn) transport through lateritic soil under pH 5 with initial concentration 4.61 mol/L

Sample #	Pore volume	Observed data Zn Conc.(mM)	C/C0	Fitted Linear C/C0	Fitted Langmuir C/C0	Fitted TSM C/C0
1	2.60	0.10	0.02	0.00	0.00	0.00
2	4.63	0.09	0.02	0.01	0.00	0.00
3	6.96	0.16	0.03	0.04	0.00	0.00
4	11.58	0.47	0.10	0.19	0.00	0.02
5	16.48	1.09	0.24	0.41	0.00	0.20
6	19.67	1.55	0.34	0.54	0.01	0.36
7	23.43	2.02	0.44	0.67	0.34	0.49
8	26.50	2.35	0.51	0.75	0.89	0.56
9	30.34	2.77	0.60	0.82	0.99	0.64
10	33.55	3.00	0.65	0.87	1.00	0.69
11	37.27	3.25	0.70	0.91	1.00	0.74
12	40.64	3.56	0.77	0.93	1.00	0.78
13	44.18	3.79	0.82	0.95	1.00	0.81
14	47.65	3.90	0.85	0.97	1.00	0.84
15	51.44	3.99	0.86	0.98	1.00	0.86
16	54.66	4.11	0.89	0.98	1.00	0.88
17	58.41	4.19	0.91	0.99	1.00	0.90
18	61.64	4.20	0.91	0.99	1.00	0.92
19	66.47	4.39	0.95	0.99	1.00	0.93
20	68.78	4.35	0.94	1.00	1.00	0.94
21	73.59	4.46	0.97	1.00	1.00	0.95
22	75.92	4.44	0.96	1.00	1.00	0.96
23	79.80	4.58	0.99	1.00	1.00	0.96
24	82.82	4.58	0.99	1.00	1.00	0.97
25	86.44	4.61	1.00	1.00	1.00	0.97
26	88.44	4.62	1.05	1.00	1.00	0.98
27	90.73	4.61	1.02	1.00	1.00	0.98
28	94.18	4.71	1.03	1.00	1.00	0.98
29	96.39	4.65	1.07	1.00	0.94	0.91
30	96.95	4.60	1.05	1.00	0.89	0.85
31	97.51	4.62	1.04	1.00	0.83	0.80
32	98.06	3.76	0.82	1.00	0.78	0.75
33	98.61	2.97	0.64	0.99	0.73	0.70
34	98.88	2.84	0.62	0.99	0.71	0.68
35	101.60	1.89	0.41	0.95	0.54	0.54
36	104.26	1.49	0.32	0.86	0.44	0.46
37	105.92	1.36	0.30	0.78	0.39	0.42
38	107.22	1.21	0.26	0.65	0.34	0.38
39	109.19	1.13	0.25	0.48	0.29	0.34

Table B.8 Observed and simulated breakthrough curves of Nickel (Ni) transport through lateritic soil under pH 5 with initial concentration 4.89 mol/L

Sample #	Pore volume	Observed data Ni Conc.(mM)	C/C0	Fitted Linear C/C0	Fitted Langmuir C/C0	Fitted TSM C/C0
1	2.40	0.00	0.00	0.00	0.00	0.00
2	2.67	0.00	0.00	0.00	0.00	0.00
3	4.30	0.00	0.00	0.03	0.00	0.00
4	4.57	0.00	0.00	0.03	0.00	0.00
5	10.69	0.65	0.05	0.37	0.00	0.00
6	13.08	0.80	0.19	0.52	0.00	0.00
7	15.52	0.95	0.29	0.65	0.00	0.02
8	18.35	1.14	0.38	0.77	0.37	0.38
9	21.87	1.36	0.46	0.86	1.00	0.53
10	24.82	1.55	0.52	0.91	1.00	0.58
11	28.13	1.77	0.58	0.95	1.00	0.62
12	31.04	1.96	0.65	0.97	1.00	0.65
13	33.84	2.15	0.68	0.98	1.00	0.68
14	37.10	2.37	0.72	0.99	1.00	0.71
15	40.34	2.59	0.75	0.99	1.00	0.74
16	43.08	2.78	0.78	1.00	1.00	0.76
17	46.35	3.00	0.80	1.00	1.00	0.79
18	49.11	3.19	0.79	1.00	1.00	0.80
19	53.10	3.46	0.84	1.00	1.00	0.83
20	54.98	3.59	0.84	1.00	1.00	0.84
21	58.97	3.87	0.85	1.00	1.00	0.86
22	60.94	4.00	0.88	1.00	1.00	0.87
23	64.18	4.24	0.88	1.00	1.00	0.88
24	66.81	4.42	0.86	1.00	1.00	0.89
25	70.63	4.68	0.91	1.00	1.00	0.90
26	72.61	4.82	0.92	1.00	1.00	0.91
27	79.32	5.30	0.94	1.00	1.00	0.93
28	85.01	5.71	1.00	1.00	1.00	0.94
29	89.71	6.05	1.02	1.00	1.00	0.95
30	90.32	6.09	1.01	1.00	0.77	0.73
31	90.80	6.13	0.76	1.00	0.65	0.61
32	91.05	6.14	0.60	1.00	0.60	0.57
33	91.28	6.16	0.60	1.00	0.56	0.53
34	92.22	6.23	0.40	0.98	0.45	0.43
35	92.68	6.26	0.36	0.97	0.41	0.39
36	93.38	6.31	0.29	0.95	0.37	0.35
37	93.85	6.35	0.29	0.92	0.35	0.33
38	94.55	6.40	0.24	0.89	0.32	0.31
39	96.90	6.57	0.19	0.72	0.25	0.25
40	99.19	6.74	0.16	0.54	0.21	0.22
41	101.45	6.91	0.14	0.39	0.19	0.21
42	103.66	7.08	0.13	0.27	0.17	0.19
43	105.88	7.25	0.12	0.19	0.15	0.18
44	108.07	7.42	0.11	0.13	0.14	0.17
45	110.23	7.59	0.11	0.08	0.13	0.16
46	113.49	7.85	0.10	0.05	0.11	0.16
47	115.62	8.02	0.10	0.03	0.11	0.15
48	117.77	8.19	0.10	0.02	0.10	0.15
49	119.87	8.36	0.09	0.01	0.10	0.14

Table B.8 Observed and simulated breakthrough curves of Nickel (Ni) transport through lateritic soil under pH 5 with initial concentration 4.89 mol/L (Continued)

50	121.93	8.53	0.08	0.01	0.09	0.14
51	123.88	8.70	0.08	0.01	0.09	0.13
52	125.51	8.85	0.08	0.00	0.00	0.00
36	93.38	6.31	0.29	0.95	0.37	0.35
37	93.85	6.35	0.29	0.92	0.35	0.33
38	94.55	6.40	0.24	0.89	0.32	0.31

Table B.9 Observed and simulated breakthrough curves of Mangnese (Mn) transport through lateritic soil under pH 5 with initial concentration 4.81 mol/L

		Observed data Mn		Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	1.67	0.00	0.00	0.00	0.00	0.00
2	2.78	0.00	0.00	0.03	0.00	0.00
3	5.57	0.04	0.01	0.18	0.00	0.03
4	6.12	0.59	0.12	0.22	0.00	0.05
5	6.97	1.04	0.22	0.28	0.00	0.11
6	8.36	1.17	0.24	0.39	0.00	0.24
7	9.77	1.39	0.29	0.48	0.00	0.36
8	12.57	1.96	0.41	0.65	0.21	0.50
9	13.98	2.22	0.46	0.71	0.61	0.54
10	16.79	2.56	0.53	0.81	0.95	0.61
11	19.56	3.14	0.65	0.87	0.99	0.66
12	22.37	3.45	0.72	0.91	1.00	0.71
13	25.15	3.57	0.74	0.94	1.00	0.75
14	29.21	3.96	0.82	0.97	1.00	0.81
15	31.95	4.05	0.84	0.98	1.00	0.83
16	34.69	4.20	0.87	0.99	1.00	0.86
17	37.46	4.25	0.88	0.99	1.00	0.88
18	40.19	4.37	0.91	0.99	1.00	0.90
19	42.98	4.53	0.94	1.00	1.00	0.91
20	45.78	4.54	0.94	1.00	1.00	0.92
21	48.62	4.62	0.96	1.00	1.00	0.94
22	51.47	4.69	0.97	1.00	1.00	0.94
23	55.63	4.51	0.94	1.00	1.00	0.96
24	58.43	4.51	0.94	1.00	1.00	0.96
25	61.24	4.69	0.98	1.00	1.00	0.97
26	64.06	4.62	0.96	1.00	1.00	0.97
27	66.85	4.66	0.97	1.00	1.00	0.98
28	69.66	4.71	0.98	1.00	1.00	0.98
29	72.45	4.69	0.98	1.00	1.00	0.98
30	75.26	4.73	0.98	1.00	1.00	0.99
31	77.77	4.64	0.96	1.00	1.00	0.99
32	78.32	4.66	0.97	1.00	1.00	0.99
33	80.77	4.62	0.96	0.99	0.78	0.69
34	81.31	3.42	0.71	0.98	0.70	0.61
35	82.13	2.19	0.46	0.95	0.60	0.52
36	83.49	1.58	0.33	0.88	0.49	0.44
37	84.85	1.25	0.26	0.79	0.42	0.38
38	87.56	0.91	0.19	0.58	0.32	0.32
39	90.28	0.72	0.15	0.40	0.27	0.29
40	93.00	0.61	0.13	0.27	0.23	0.26
41	95.71	0.54	0.11	0.18	0.20	0.24
42	98.33	0.50	0.10	0.12	0.17	0.23
43	100.79	0.44	0.09	0.08	0.15	0.21
44	103.00	0.41	0.09	0.05	0.14	0.20

Table B.10 Observed, predicted and simulated breakthrough curves of Nickel (Ni) transport through lateritic soil under pH 4 with initial concentration 5.28 mmol/L

Sample #	Pore volume	Observed data Pb Conc.(mM)	C/C0	Predicted Langmuir C/C0	Linear C/C0	Fitted Langmuir C/C0	TSM C/C0
1	0.00	0.00	0.00	0.00	0.01	0.00	0.00
2	1.60	0.01	0.00	0.00	0.02	0.00	0.00
3	2.91	0.16	0.03	0.00	0.08	0.00	0.01
4	5.22	0.88	0.17	0.00	0.28	0.01	0.12
5	8.20	2.18	0.41	0.08	0.53	0.22	0.42
6	9.68	2.57	0.49	0.24	0.64	0.53	0.54
7	10.61	2.94	0.56	0.40	0.71	0.71	0.60
8	13.30	3.68	0.70	0.77	0.83	0.94	0.72
9	14.51	4.00	0.76	0.87	0.87	0.97	0.76
10	18.97	4.52	0.86	0.98	0.95	1.00	0.87
11	21.65	4.53	0.86	0.99	0.97	1.00	0.91
12	24.55	5.15	0.97	1.00	0.99	1.00	0.94
13	26.87	5.27	1.00	1.00	0.99	1.00	0.96
14	29.35	5.28	1.00	1.00	1.00	1.00	0.97
15	31.30	5.32	1.01	1.00	1.00	1.00	0.98
16	33.41	5.40	1.02	1.00	1.00	1.00	0.99
17	35.70	5.45	1.03	1.00	1.00	1.00	0.99
18	37.48	5.49	1.04	1.00	1.00	1.00	0.99
19	39.03	5.50	1.04	1.00	1.00	1.00	1.00
20	43.20	5.52	1.04	1.00	1.00	1.00	1.00
21	45.52	5.48	1.04	1.00	1.00	1.00	1.00
22	46.60	5.49	1.04	1.00	1.00	1.00	1.00
23	49.03	5.48	1.04	1.00	1.00	1.00	1.00
24	49.36	5.91	1.12	1.00	1.00	1.00	1.00
25	49.82	5.98	1.13	1.00	1.00	0.99	0.94
26	50.29	4.70	0.89	0.99	0.99	0.93	0.81
27	50.91	3.34	0.63	0.94	0.95	0.82	0.66
28	52.45	1.95	0.37	0.70	0.77	0.58	0.47
29	53.15	1.67	0.32	0.61	0.65	0.49	0.42
30	54.63	1.37	0.26	0.46	0.43	0.37	0.35
31	57.76	1.02	0.19	0.28	0.15	0.22	0.25
32	59.48	0.94	0.18	0.22	0.08	0.17	0.22
33	60.95	0.86	0.16	0.18	0.04	0.14	0.19
34	62.89	0.88	0.17	0.14	0.02	0.11	0.16

APPENDIX C: COLUMN EXPERIMENT DATA FOR BINARY AND MULTI-METAL SYSTEM

Table C.1 Observed, predicted and simulated breakthrough curves of Lead (Pb^{2+}) and Nickel (Ni^{2+}) transport through lateritic soil under pH 5 with initial concentration 4.86 mmol/L for Pb^{2+} and 3.01 mmol/L for Ni^{2+}

	Observed data Pb			Fitted				Observed data Ni			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	1.08	0.00	0.00	0.00	0.00	0.00	1	1.08	0.00	0.00	0.00	0.00	0.00
2	3.52	0.00	0.00	0.01	0.00	0.00	2	3.52	0.00	0.00	0.03	0.00	0.00
3	5.42	0.00	0.00	0.04	0.00	0.00	3	5.42	0.00	0.00	0.11	0.00	0.00
4	7.61	0.00	0.00	0.12	0.00	0.00	4	7.61	0.16	0.05	0.26	0.00	0.00
5	10.08	0.11	0.02	0.26	0.00	0.00	5	10.08	0.63	0.21	0.45	0.00	0.00
6	10.91	0.36	0.08	0.31	0.00	0.00	6	10.91	0.76	0.25	0.51	0.00	0.00
7	13.11	0.71	0.15	0.44	0.00	0.00	7	13.11	0.83	0.28	0.64	0.00	0.00
8	16.70	1.35	0.29	0.62	0.00	0.27	8	14.22	1.16	0.39	0.70	0.00	0.00
9	19.73	1.97	0.42	0.73	0.43	0.50	9	16.70	1.66	0.55	0.80	0.56	0.00
10	23.43	2.56	0.55	0.83	1.00	0.59	10	19.73	2.12	0.70	0.88	1.00	0.00
11	26.48	2.96	0.63	0.88	1.00	0.66	11	23.43	2.43	0.81	0.93	1.00	0.00
12	30.12	3.33	0.71	0.92	1.00	0.72	12	26.48	2.57	0.85	0.96	1.00	0.00
13	33.19	3.51	0.75	0.95	1.00	0.77	13	30.12	2.73	0.91	0.98	1.00	0.00
14	36.81	3.74	0.80	0.97	1.00	0.81	14	33.19	2.79	0.93	0.99	1.00	0.00
15	39.59	3.89	0.83	0.98	1.00	0.84	15	36.81	2.90	0.96	0.99	1.00	0.00
16	43.37	4.10	0.88	0.99	1.00	0.87	16	39.59	2.88	0.96	1.00	1.00	0.00
17	46.96	4.16	0.89	0.99	1.00	0.90	17	43.37	2.98	0.99	1.00	1.00	0.00
18	49.86	4.45	0.95	1.00	1.00	0.92	18	46.96	2.91	0.97	1.00	1.00	0.00
19	52.85	4.46	0.95	1.00	1.00	0.93	19	49.86	2.96	0.98	1.00	1.00	0.00
20	56.40	4.56	0.98	1.00	1.00	0.95	20	52.85	2.97	0.99	1.00	1.00	0.00
21	59.47	4.54	0.97	1.00	1.00	0.95	21	56.40	3.00	1.00	1.00	1.00	0.00
22	63.04	4.60	0.98	1.00	1.00	0.96	22	59.47	2.96	0.98	1.00	1.00	0.00
23	66.07	4.57	0.98	1.00	1.00	0.97	23	63.04	2.99	0.99	1.00	1.00	0.00

Table C.1 Observed, predicted and simulated breakthrough curves of Lead (Pb^{2+}) and Nickel (Ni^{2+}) transport through lateritic soil under pH 5 with initial concentration 4.86 mmol/L for Pb^{2+} and 3.01 mmol/L for Ni^{2+} (Continued)

24	69.69	4.69	1.00	1.00	1.00	0.97	24	66.07	3.05	1.01	1.00	1.00	0.00
25	72.71	4.77	1.02	1.00	1.00	0.98	25	69.69	3.01	1.00	1.00	1.00	0.00
26	76.27	4.77	1.02	1.00	1.00	0.98	26	72.71	3.07	1.02	1.00	1.00	0.00
27	78.20	4.90	1.05	1.00	1.00	0.98	27	76.27	3.04	1.01	1.00	1.00	0.00
28	82.89	4.80	1.03	1.00	0.99	0.99	28	78.20	3.02	1.00	1.00	1.00	0.00
29	84.64	3.03	0.65	1.00	0.56	0.52	29	82.89	2.86	0.95	1.00	0.94	0.00
30	85.47	2.64	0.57	0.99	0.47	0.43	30	84.37	2.01	0.67	0.99	0.54	0.00
31	85.74	2.14	0.46	0.99	0.44	0.41	31	84.64	1.60	0.53	0.98	0.51	0.00
32	86.02	1.81	0.39	0.98	0.42	0.39	32	85.47	1.33	0.44	0.97	0.43	0.00
33	86.29	1.62	0.35	0.98	0.40	0.37	33	85.74	1.15	0.38	0.96	0.41	0.00
34	89.34	0.92	0.20	0.88	0.29	0.28	34	86.02	0.91	0.30	0.95	0.39	0.00
35	92.35	0.65	0.14	0.71	0.23	0.24	35	86.29	0.78	0.26	0.94	0.37	0.00
36	95.64	0.58	0.12	0.51	0.19	0.21	36	89.34	0.42	0.14	0.74	0.27	0.00
37	98.92	0.39	0.08	0.36	0.17	0.19	37	92.35	0.32	0.11	0.52	0.21	0.00
38	102.54	0.33	0.07	0.25	0.15	0.18	38	95.64	0.34	0.11	0.31	0.18	0.00
39	107.10	0.32	0.07	0.14	0.13	0.16	39	98.92	0.31	0.10	0.19	0.16	0.00
40	108.74	0.29	0.06	0.10	0.12	0.16	40	102.54	0.28	0.09	0.11	0.14	0.00
41	111.90	0.28	0.06	0.07	0.11	0.15	41	107.10	0.25	0.08	0.05	0.12	0.00
42	116.84	0.27	0.06	0.03	0.10	0.13	42	108.74	0.24	0.08	0.03	0.11	0.00
43	0.00	0.00	0.00	0.00	0.00	0.00	43	111.90	0.23	0.08	0.02	0.10	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00	44	116.84	0.20	0.07	0.01	0.09	0.00

Table C.2 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Nickel (Ni2+) transport through lateritic soil under pH 5 with initial concentration 4.85 mmol/L for Pb2+ and 3.17mmol/L for Ni2+ (Duplicated)

	Observed data Pb			Fitted				Observed data Ni			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	1.61	0.00	0.00	0.00	0.00	0.00	1	1.61	0.00	0.00	0.00	0.00	0.00
2	3.93	0.00	0.00	0.02	0.00	0.00	2	3.93	0.00	0.00	0.11	0.00	0.00
3	6.63	0.00	0.00	0.11	0.00	0.00	3	6.63	0.11	0.04	0.36	0.00	0.00
4	9.32	0.27	0.05	0.27	0.00	0.00	4	9.32	0.64	0.20	0.60	0.00	0.02
5	10.67	0.52	0.11	0.35	0.00	0.00	5	10.67	0.94	0.30	0.69	0.00	0.31
6	12.02	1.02	0.21	0.44	0.00	0.00	6	12.02	1.52	0.48	0.77	0.00	0.51
7	14.74	1.47	0.30	0.59	0.00	0.28	7	14.74	1.73	0.54	0.87	0.00	0.63
8	17.33	2.04	0.42	0.70	0.00	0.48	8	17.33	2.13	0.67	0.93	0.00	0.71
9	20.02	2.50	0.52	0.79	0.52	0.55	9	20.02	2.35	0.74	0.96	0.74	0.77
10	22.53	2.78	0.57	0.86	1.00	0.61	10	22.53	2.53	0.80	0.98	1.00	0.82
11	24.99	3.03	0.63	0.90	1.00	0.66	11	24.99	2.66	0.84	0.99	1.00	0.86
12	29.17	3.37	0.70	0.94	1.00	0.72	12	29.17	2.94	0.93	1.00	1.00	0.90
13	31.94	3.78	0.78	0.96	1.00	0.75	13	31.94	3.05	0.96	1.00	1.00	0.92
14	34.72	3.83	0.79	0.97	1.00	0.78	14	34.72	3.02	0.95	1.00	1.00	0.94
15	37.50	3.88	0.80	0.98	1.00	0.81	15	37.50	3.08	0.97	1.00	1.00	0.95
16	40.31	4.00	0.83	0.99	1.00	0.84	16	40.31	3.08	0.97	1.00	1.00	0.96
17	43.13	4.04	0.83	0.99	1.00	0.86	17	43.13	3.15	1.00	1.00	1.00	0.97
18	45.95	4.12	0.85	0.99	1.00	0.87	18	45.95	3.13	0.99	1.00	1.00	0.98
19	48.80	4.18	0.86	1.00	1.00	0.89	19	48.80	3.24	1.02	1.00	1.00	0.98
20	51.66	4.30	0.89	1.00	1.00	0.90	20	51.66	3.26	1.03	1.00	1.00	0.99
21	55.86	4.57	0.94	1.00	1.00	0.92	21	55.86	3.33	1.05	1.00	1.00	0.99
22	58.70	4.63	0.95	1.00	1.00	0.93	22	58.70	3.19	1.01	1.00	1.00	0.99
23	61.49	4.72	0.97	1.00	1.00	0.94	23	61.49	3.20	1.01	1.00	1.00	0.99
24	64.29	4.83	1.00	1.00	1.00	0.95	24	64.29	3.30	1.04	1.00	1.00	1.00

Table C.2 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Nickel (Ni2+) transport through lateritic soil under pH 5 with initial concentration 4.85 mmol/L for Pb2+ and 3.17mmol/L for Ni2+ (Duplicated) (Continued)

25	67.07	4.82	0.99	1.00	1.00	0.95	25	67.07	3.23	1.02	1.00	1.00	1.00
26	69.89	4.75	0.98	1.00	1.00	0.96	26	69.89	3.26	1.03	1.00	1.00	1.00
27	72.69	4.81	0.99	1.00	1.00	0.97	27	72.69	3.22	1.02	1.00	1.00	1.00
28	75.53	4.73	0.98	1.00	1.00	0.97	28	75.53	3.21	1.01	1.00	1.00	1.00
29	78.40	4.84	1.00	1.00	1.00	0.97	29	78.40	3.18	1.00	1.00	1.00	1.00
30	82.74	4.88	1.01	1.00	1.00	0.98	30	82.74	3.23	1.02	1.00	1.00	1.00
31	85.61	4.89	1.01	1.00	1.00	0.98	31	85.61	3.12	0.99	1.00	1.00	1.00
32	88.50	4.98	1.03	1.00	1.00	0.98	32	88.50	3.12	0.99	1.00	1.00	1.00
33	91.44	4.86	1.00	1.00	1.00	0.99	33	91.44	3.09	0.97	1.00	1.00	1.00
34	92.94	4.98	1.03	1.00	1.00	0.99	34	92.94	3.16	1.00	1.00	1.00	1.00
35	93.52	4.98	1.03	1.00	0.92	0.89	35	93.52	3.26	1.03	1.00	0.87	0.86
36	94.12	4.36	0.90	1.00	0.72	0.67	36	94.12	2.78	0.88	1.00	0.64	0.62
37	94.73	2.99	0.62	1.00	0.58	0.54	37	94.73	1.78	0.56	0.99	0.50	0.48
38	95.34	2.33	0.48	1.00	0.49	0.45	38	95.34	1.23	0.39	0.98	0.41	0.41
39	95.94	1.80	0.37	1.00	0.43	0.40	39	95.94	0.98	0.31	0.97	0.36	0.36
40	96.54	1.43	0.29	0.99	0.38	0.36	40	96.54	0.81	0.26	0.94	0.32	0.32
41	97.14	1.27	0.26	0.98	0.35	0.33	41	97.14	0.64	0.20	0.91	0.29	0.30
42	98.95	1.00	0.21	0.94	0.28	0.28	42	98.95	0.39	0.12	0.77	0.23	0.25
43	100.45	0.90	0.19	0.89	0.25	0.25	43	100.45	0.34	0.11	0.64	0.21	0.23
44	103.43	0.70	0.14	0.73	0.20	0.22	44	103.43	0.25	0.08	0.40	0.17	0.20
45	106.41	0.65	0.13	0.57	0.17	0.20	45	110.72	0.26	0.08	0.10	0.12	0.15
46	110.72	0.56	0.12	0.35	0.14	0.18	46	113.47	0.21	0.06	0.05	0.11	0.14
47	113.47	0.54	0.11	0.25	0.13	0.17	47	116.21	0.18	0.06	0.03	0.10	0.13
48	116.21	0.52	0.11	0.17	0.12	0.16	48	118.90	0.15	0.05	0.02	0.10	0.13
49	118.90	0.42	0.09	0.12	0.11	0.15	49	121.60	0.22	0.07	0.01	0.09	0.12
50	121.60	0.46	0.10	0.08	0.11	0.15	50	124.32	0.21	0.07	0.00	0.08	0.11
51	124.32	0.44	0.09	0.06	0.10	0.14	51	127.01	0.19	0.06	0.00	0.08	0.11
52	127.01	0.40	0.08	0.04	0.09	0.14	52	129.75	0.19	0.06	0.00	0.08	0.10
53	129.75	0.40	0.08	0.03	0.09	0.13	53	132.42	0.18	0.06	0.00	0.07	0.10

Table C.2 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Nickel (Ni2+) transport through lateritic soil under pH 5 with initial concentration 4.85 mmol/L for Pb2+ and 3.17mmol/L for Ni2+ (Duplicated) (Continued)

54	132.42	0.38	0.08	0.02	0.08	0.12	54	136.15	0.22	0.07	0.00	0.07	0.09
55	136.15	0.44	0.09	0.01	0.08	0.12	55	0.00	0.00	0.00	0.00	0.00	0.00

Table C.3 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Nickel (Ni2+) transport through lateritic soil under pH 5 with initial concentration 4.93 mmol/L for Pb2+ and 5.13 mmol/L for Ni2+

	Observed data Pb			Fitted				Observed data Ni			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	1.07	0.00	0.00	0.00	0.00	0.00	1	1.07	0.00	0.00	0.00	0.00	0.00
2	2.96	0.00	0.00	0.00	0.00	0.00	2	2.96	0.00	0.00	0.03	0.00	0.00
3	4.94	0.00	0.00	0.03	0.00	0.00	3	4.94	0.00	0.00	0.14	0.00	0.00
4	7.00	0.00	0.00	0.11	0.00	0.00	4	7.00	8.07	0.03	0.34	0.00	0.00
5	9.46	0.00	0.00	0.24	0.00	0.00	5	9.46	54.94	0.18	0.55	0.09	0.09
6	10.27	0.00	0.00	0.29	0.00	0.00	6	10.27	73.24	0.24	0.61	0.30	0.27
7	12.43	0.31	0.06	0.42	0.00	0.00	7	12.43	132.21	0.44	0.74	0.89	0.56
8	15.62	1.11	0.22	0.61	0.00	0.21	8	15.62	215.24	0.72	0.87	1.00	0.73
9	18.55	2.12	0.43	0.73	0.00	0.53	9	18.55	263.58	0.88	0.93	1.00	0.82
10	21.85	2.99	0.61	0.83	0.62	0.64	10	21.85	280.78	0.93	0.97	1.00	0.89
11	24.41	3.49	0.71	0.88	1.00	0.71	11	24.41	286.66	0.95	0.98	1.00	0.93
12	28.32	4.19	0.85	0.93	1.00	0.78	12	28.32	296.03	0.98	0.99	1.00	0.96
13	30.45	4.18	0.85	0.95	1.00	0.82	13	30.45	290.58	0.97	1.00	1.00	0.97
14	34.08	4.36	0.88	0.97	1.00	0.86	14	34.08	290.30	0.96	1.00	1.00	0.98
15	36.79	4.38	0.89	0.98	1.00	0.88	15	36.79	289.04	0.96	1.00	1.00	0.99
16	40.72	4.47	0.91	0.99	1.00	0.91	16	40.72	296.17	0.98	1.00	1.00	0.99
17	44.40	4.53	0.92	0.99	1.00	0.93	17	44.40	289.18	0.96	1.00	1.00	1.00
18	47.32	4.64	0.94	1.00	1.00	0.95	18	47.32	292.89	0.97	1.00	1.00	1.00
19	50.49	4.64	0.94	1.00	1.00	0.95	19	50.49	293.45	0.97	1.00	1.00	1.00
20	54.11	4.81	0.98	1.00	1.00	0.97	20	54.11	294.63	0.98	1.00	1.00	1.00
21	57.26	4.81	0.98	1.00	1.00	0.97	21	57.26	294.28	0.98	1.00	1.00	1.00
22	60.78	4.76	0.97	1.00	1.00	0.98	22	60.78	292.47	0.97	1.00	1.00	1.00
23	63.80	4.79	0.97	1.00	1.00	0.98	23	63.80	294.00	0.98	1.00	1.00	1.00
24	67.44	4.74	0.96	1.00	1.00	0.99	24	67.44	294.42	0.98	1.00	1.00	1.00
25	70.43	4.75	0.96	1.00	1.00	0.99	25	70.43	296.31	0.98	1.00	1.00	1.00

Table C.3 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Nickel (Ni2+) transport through lateritic soil under pH 5 with initial concentration 4.93 mmol/L for Pb2+ and 5.13 mmol/L for Ni2+ (Continued)

26	73.65	4.83	0.98	1.00	1.00	0.99	26	73.65	296.45	0.98	1.00	1.00	1.00
27	75.77	4.97	1.01	1.00	1.00	0.99	27	75.77	296.19	0.98	1.00	1.00	1.00
28	80.19	4.28	0.87	1.00	0.99	0.97	28	80.19	301.29	1.00	1.00	1.00	0.98
29	81.63	3.06	0.62	1.00	0.52	0.44	29	81.63	204.32	0.68	0.98	0.75	0.47
30	81.93	2.46	0.50	1.00	0.49	0.41	30	81.93	161.44	0.54	0.97	0.71	0.44
31	82.14	2.14	0.43	0.99	0.46	0.38	31	82.14	134.57	0.45	0.96	0.67	0.42
32	82.60	1.65	0.34	0.99	0.41	0.35	32	82.60	95.09	0.32	0.94	0.61	0.38
33	82.87	1.46	0.30	0.99	0.39	0.33	33	82.87	85.28	0.28	0.92	0.58	0.36
34	83.63	0.64	0.13	0.88	0.27	0.24	34	83.63	40.75	0.14	0.64	0.38	0.27
35	86.66	0.57	0.12	0.71	0.21	0.21	35	86.66	28.86	0.10	0.39	0.28	0.23
36	90.16	0.62	0.13	0.50	0.18	0.19	36	90.16	19.04	0.06	0.20	0.22	0.19
37	92.69	0.53	0.11	0.36	0.16	0.17	37	92.69	15.75	0.05	0.11	0.18	0.17
38	95.64	0.47	0.10	0.24	0.14	0.16	38	95.64	14.05	0.05	0.05	0.15	0.15
39	98.50	0.41	0.08	0.14	0.12	0.14	39	98.50	12.68	0.04	0.02	0.12	0.13
40	100.82	0.40	0.08	0.13	0.11	0.13	40	100.82	12.71	0.04	0.01	0.10	0.13

Table C.4 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Nickel (Ni2+) transport through lateritic soil under pH 5 with initial concentration 4.88 mmol/L for Pb2+ and 10.06 mmol/L for Ni2+

Sample #	Observed data Pb			Fitted			Sample #	Observed data Ni			Fitted		
	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0		Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	0.48	0.00	0.00	0.00	0.00	0.00	1	0.48	0.00	0.00	0.00	0.00	0.00
2	2.17	0.00	0.00	0.01	0.00	0.00	2	2.17	0.00	0.00	0.05	0.00	0.00
3	4.60	0.00	0.00	0.08	0.00	0.00	3	4.60	0.29	0.03	0.30	0.00	0.01
4	7.03	0.00	0.00	0.23	0.00	0.00	4	5.82	1.88	0.19	0.45	0.00	0.09
5	9.45	0.10	0.02	0.41	0.00	0.00	5	7.03	3.45	0.34	0.58	0.23	0.37
6	11.88	0.96	0.20	0.57	0.00	0.14	6	8.24	4.65	0.46	0.69	0.89	0.57
7	14.30	1.88	0.39	0.70	0.00	0.53	7	9.45	6.66	0.66	0.77	0.99	0.68
8	16.74	2.51	0.51	0.80	0.00	0.61	8	10.67	7.22	0.72	0.84	1.00	0.75
9	19.16	3.15	0.65	0.86	0.63	0.67	9	13.09	8.69	0.86	0.92	1.00	0.85
10	21.58	3.56	0.73	0.91	1.00	0.72	10	15.53	9.30	0.92	0.96	1.00	0.91
11	25.23	3.91	0.80	0.95	1.00	0.78	11	16.74	9.43	0.94	0.97	1.00	0.93
12	27.65	4.20	0.86	0.97	1.00	0.81	12	19.16	9.63	0.96	0.98	1.00	0.96
13	30.08	4.28	0.88	0.98	1.00	0.84	13	21.58	9.74	0.97	0.99	1.00	0.97
14	32.50	4.35	0.89	0.99	1.00	0.86	14	25.23	9.97	0.99	1.00	1.00	0.99
15	37.33	4.56	0.93	0.99	1.00	0.90	15	27.65	9.82	0.98	1.00	1.00	0.99
16	39.75	4.55	0.93	1.00	1.00	0.92	16	30.08	9.78	0.97	1.00	1.00	1.00
17	42.17	4.59	0.94	1.00	1.00	0.93	17	32.50	9.89	0.98	1.00	1.00	1.00
18	44.57	4.67	0.96	1.00	1.00	0.94	18	37.33	9.88	0.98	1.00	1.00	1.00
19	48.14	4.68	0.96	1.00	1.00	0.95	19	39.75	9.85	0.98	1.00	1.00	1.00
20	50.51	4.60	0.94	1.00	1.00	0.96	20	42.17	9.91	0.98	1.00	1.00	1.00
21	52.92	4.70	0.96	1.00	1.00	0.97	21	44.57	10.09	1.00	1.00	1.00	1.00
22	55.35	4.61	0.94	1.00	1.00	0.97	22	48.14	10.02	1.00	1.00	1.00	1.00
23	57.77	4.38	0.90	1.00	1.00	0.98	23	50.51	9.91	0.99	1.00	1.00	1.00
24	58.25	4.74	0.97	1.00	0.93	0.90	24	52.92	9.98	0.99	1.00	1.00	1.00

Table C.4 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Nickel (Ni2+) transport through lateritic soil under pH 5 with initial concentration 4.88 mmol/L for Pb2+ and 10.06 mmol/L for Ni2+ (Continued)

25	58.73	4.70	0.96	1.00	0.74	0.70	25	55.35	9.81	0.98	1.00	1.00	1.00
26	59.22	3.88	0.80	1.00	0.60	0.57	26	57.77	7.87	0.86	1.00	1.00	1.00
27	59.46	3.15	0.65	1.00	0.55	0.52	27	58.25	8.82	0.97	1.00	0.96	0.94
28	59.70	2.47	0.51	1.00	0.51	0.48	28	59.22	8.58	0.94	0.99	0.68	0.63
29	59.95	1.99	0.41	1.00	0.47	0.45	29	59.46	7.92	0.87	0.98	0.62	0.58
30	60.19	1.64	0.34	0.99	0.44	0.42	30	59.70	6.60	0.72	0.97	0.58	0.54
31	62.58	0.84	0.17	0.92	0.29	0.29	31	59.95	4.11	0.45	0.96	0.54	0.51
32	64.98	0.56	0.11	0.77	0.23	0.24	32	60.19	3.38	0.37	0.95	0.50	0.48
33	67.37	0.47	0.10	0.59	0.19	0.21	33	62.58	1.59	0.17	0.70	0.31	0.33
34	70.94	0.37	0.08	0.36	0.16	0.18	34	64.98	1.09	0.12	0.41	0.23	0.27
35	73.31	0.37	0.08	0.25	0.14	0.17	35	67.37	0.90	0.10	0.23	0.18	0.23
36	75.67	0.32	0.06	0.17	0.13	0.16	36	70.94	0.76	0.08	0.08	0.14	0.18
37	77.98	0.32	0.07	0.11	0.12	0.15	37	73.31	0.72	0.08	0.04	0.12	0.16
38	80.33	0.31	0.06	0.08	0.11	0.14	38	75.67	0.68	0.07	0.02	0.11	0.14
39	82.65	0.32	0.06	0.05	0.11	0.14	39	77.98	0.71	0.08	0.01	0.09	0.13
40	84.92	0.25	0.05	0.03	0.10	0.13	40	80.33	0.65	0.07	0.01	0.08	0.12
41	87.09	0.28	0.06	0.02	0.09	0.12	41	82.65	0.59	0.06	0.00	0.07	0.10
42	89.23	0.32	0.07	0.01	0.09	0.12	42	84.92	0.61	0.07	0.00	0.07	0.09
43	0.00	0.00	0.00	0.00	0.00	0.00	43	87.09	0.58	0.06	0.00	0.06	0.09
44	0.00	0.00	0.00	0.00	0.00	0.00	44	89.23	0.53	0.06	0.00	0.05	0.08

Table C.5 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.26 mmol/L for Pb2+ and 2.91 mmol/L for Zn2+

	Observed data Pb			Fitted				Observed data Zn			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	1.77	0.01	0.00	0.00	0.00	0.00	1	1.77	0.02	0.01	0.04	0.00	0.00
2	4.19	0.02	0.00	0.07	0.00	0.00	2	3.95	0.11	0.04	0.31	0.00	0.00
3	6.31	0.17	0.03	0.22	0.00	0.00	3	6.09	0.57	0.19	0.62	0.00	0.14
4	8.53	0.57	0.11	0.41	0.00	0.01	4	8 30	1.05	0.36	0.81	0.38	0.50
5	10.53	1.22	0.23	0.56	0.00	0.19	5	10.53	1.59	0.55	0.91	1.00	0.63
6	12.75	1.82	0.35	0.69	0.00	0.44	6	12.75	2.02	0.69	0.96	1.00	0.72
7	14.94	2.47	0.47	0.79	0.00	0.55	7	14.94	2.31	0.79	0.98	1.00	0.79
8	17.15	2.97	0.56	0.86	0.58	0.63	8	17.15	2.46	0.84	0.99	1.00	0.84
9	19.35	3.34	0.63	0.91	1.00	0.70	9	19.35	2.83	0.97	1.00	1.00	0.88
10	22.49	4.26	0.81	0.95	1.00	0.77	10	22.49	2.83	0.97	1.00	1.00	0.92
11	24.77	4.51	0.86	0.97	1.00	0.81	11	24.77	2.78	0.96	1.00	1.00	0.94
12	27.02	4.49	0.85	0.98	1.00	0.85	12	27.02	2.79	0.96	1.00	1.00	0.96
13	29.29	4.75	0.90	0.99	1.00	0.87	13	29.29	2.80	0.96	1.00	1.00	0.97
14	31.57	4.96	0.94	0.99	1.00	0.90	14	31.57	2.81	0.97	1.00	1.00	0.97
15	33.85	5.07	0.96	0.99	1.00	0.92	15	33.85	2.82	0.97	1.00	1.00	0.98
16	36.15	5.21	0.99	1.00	1.00	0.93	16	36.15	2.83	0.97	1.00	1.00	0.99
17	38.43	5.19	0.99	1.00	1.00	0.94	17	38.43	2.85	0.98	1.00	1.00	0.99
18	40.72	5.32	1.01	1.00	1.00	0.95	18	40.72	2.87	0.99	1.00	1.00	0.99
19	44.14	5.06	0.96	1.00	1.00	0.97	19	44.14	2.85	0.98	1.00	1.00	0.99
20	46.43	4.91	0.93	1.00	1.00	0.97	20	46.43	3.00	1.03	1.00	1.00	1.00
21	48.74	5.11	0.97	1.00	1.00	0.98	21	48.74	2.89	0.99	1.00	1.00	1.00
22	51.05	5.17	0.98	1.00	1.00	0.98	22	51.05	2.93	1.01	1.00	1.00	1.00
23	53.38	4.99	0.95	1.00	1.00	0.98	23	53.38	2.91	1.00	1.00	1.00	1.00
24	55.69	5.11	0.97	1.00	1.00	0.99	24	55.69	2.87	0.99	1.00	1.00	1.00

Table C.5 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.26 mmol/L for Pb2+ and 2.91 mmol/L for Zn2+ (Continued)

25	58.00	4.88	0.93	1.00	1.00	0.99	25	58.00	2.92	1.00	1.00	1.00	1.00
26	60.31	5.16	0.98	1.00	1.00	0.99	26	60.31	2.81	0.97	1.00	1.00	1.00
27	62.64	4.94	0.94	1.00	1.00	0.99	27	62.64	2.71	0.93	1.00	1.00	1.00
28	64.97	5.27	1.00	1.00	1.00	0.99	28	64.97	2.89	0.99	1.00	1.00	1.00
29	65.20	5.17	0.98	1.00	1.00	0.99	29	65.20	2.88	0.99	1.00	1.00	1.00
30	65.43	5.07	0.96	1.00	0.99	0.98	30	65.43	2.85	0.98	1.00	0.99	0.98
31	65.67	5.01	0.95	1.00	0.93	0.89	31	65.67	2.79	0.96	1.00	0.92	0.90
32	65.90	4.95	0.94	1.00	0.84	0.78	32	65.90	2.81	0.97	1.00	0.82	0.79
33	66.13	4.59	0.87	1.00	0.75	0.68	33	66.13	2.58	0.89	1.00	0.72	0.69
34	66.37	4.04	0.77	1.00	0.68	0.60	34	66.37	2.19	0.75	0.99	0.64	0.61
35	66.60	2.98	0.57	1.00	0.62	0.54	35	66.60	1.72	0.59	0.99	0.58	0.55
36	66.83	2.32	0.44	1.00	0.57	0.49	36	66.83	1.31	0.45	0.98	0.53	0.50
37	67.30	1.86	0.35	1.00	0.49	0.43	37	67.30	0.99	0.34	0.95	0.45	0.44
38	68.00	1.15	0.22	0.99	0.41	0.37	38	68.00	0.77	0.27	0.88	0.38	0.38
39	68.47	1.09	0.21	0.98	0.38	0.34	39	68.47	0.66	0.23	0.82	0.34	0.35
40	70.79	0.98	0.19	0.86	0.27	0.27	40	70.79	0.41	0.14	0.49	0.24	0.27
41	73.09	0.83	0.16	0.69	0.22	0.24	41	73.09	0.34	0.12	0.25	0.19	0.24
42	75.39	0.71	0.14	0.51	0.19	0.22	42	75.39	0.29	0.10	0.12	0.16	0.21
43	77.51	0.67	0.13	0.36	0.17	0.20	43	77.51	0.27	0.09	0.06	0.14	0.19
44	79.50	0.59	0.11	0.24	0.15	0.19	44	79.50	0.24	0.08	0.03	0.12	0.17
45	81.39	0.53	0.10	0.17	0.14	0.17	45	81.39	0.23	0.08	0.01	0.11	0.16
46	83.13	0.48	0.09	0.11	0.13	0.16	46	83.13	0.20	0.07	0.01	0.10	0.15
47	85.40	0.41	0.08	0.06	0.12	0.15	47	85.40	0.19	0.06	0.00	0.09	0.13
48	90.53	0.37	0.07	0.04	0.11	0.14	48	90.53	0.16	0.06	0.00	0.08	0.12

Table C.6 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.22 mmol/L for Pb2+ and 5.36 mmol/L for Zn2+

	Observed data Pb			Fitted				Observed data Zn			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	0.23	0.00	0.00	0.00	0.00	0.00	1	0.23	0.00	0.00	0.00	0.00	0.00
2	1.79	0.00	0.00	0.00	0.00	0.00	2	1.79	0.12	0.02	0.11	0.00	0.00
3	4.00	0.00	0.00	0.06	0.00	0.00	3	4.00	0.20	0.04	0.57	0.00	0.00
4	6.32	0.04	0.01	0.21	0.00	0.00	4	6.32	1.08	0.20	0.84	0.00	0.17
5	8.56	0.48	0.09	0.39	0.00	0.00	5	8.56	2.31	0.43	0.95	0.00	0.61
6	10.93	1.01	0.19	0.56	0.00	0.14	6	10.93	3.75	0.70	0.98	0.73	0.74
7	13.28	1.93	0.37	0.69	0.00	0.48	7	13.28	4.53	0.84	0.99	1.00	0.82
8	15.52	2.63	0.50	0.79	0.52	0.59	8	15.52	4.99	0.93	1.00	1.00	0.88
9	17.94	3.43	0.66	0.86	1.00	0.68	9	17.94	5.17	0.96	1.00	1.00	0.92
10	20.28	3.86	0.74	0.91	1.00	0.75	10	20.28	5.29	0.99	1.00	1.00	0.94
11	23.83	4.31	0.83	0.95	1.00	0.82	11	23.83	5.27	0.98	1.00	1.00	0.97
12	26.12	4.57	0.88	0.97	1.00	0.86	12	26.12	5.25	0.98	1.00	1.00	0.98
13	28.39	4.64	0.89	0.98	1.00	0.89	13	28.39	5.23	0.97	1.00	1.00	0.99
14	30.65	4.91	0.94	0.99	1.00	0.91	14	30.65	5.30	0.99	1.00	1.00	0.99
15	32.89	5.12	0.98	0.99	1.00	0.93	15	32.89	5.30	0.99	1.00	1.00	0.99
16	35.19	5.00	0.96	0.99	1.00	0.94	16	35.19	5.21	0.97	1.00	1.00	1.00
17	37.44	5.06	0.97	1.00	1.00	0.96	17	37.44	5.26	0.98	1.00	1.00	1.00
18	39.80	5.09	0.98	1.00	1.00	0.97	18	39.80	5.25	0.98	1.00	1.00	1.00
19	42.08	5.13	0.98	1.00	1.00	0.97	19	42.08	5.33	0.99	1.00	1.00	1.00
20	45.52	5.22	1.00	1.00	1.00	0.98	20	45.52	5.38	1.00	1.00	1.00	1.00
21	47.67	5.26	1.01	1.00	1.00	0.98	21	47.67	5.34	1.00	1.00	1.00	1.00
22	49.93	4.96	0.95	1.00	1.00	0.99	22	49.93	5.21	0.97	1.00	1.00	1.00
23	52.21	5.33	1.02	1.00	1.00	0.99	23	52.21	5.63	1.05	1.00	1.00	1.00
24	54.40	5.34	1.02	1.00	1.00	0.99	24	54.40	5.53	1.03	1.00	1.00	1.00

Table C.6 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.22 mmol/L for Pb2+ and 5.36 mmol/L for Zn2+ (Continued)

25	55.09	5.04	0.97	1.00	1.00	0.99	25	55.09	5.43	1.01	1.00	1.00	1.00
26	55.31	6.22	1.19	1.00	0.99	0.98	26	55.31	6.23	1.16	1.00	0.99	0.99
27	55.55	5.04	0.97	1.00	0.89	0.90	27	55.55	5.13	0.96	1.00	0.92	0.90
28	55.78	4.92	0.94	1.00	0.76	0.78	28	55.78	5.08	0.95	0.99	0.80	0.77
29	56.02	4.49	0.86	1.00	0.65	0.67	29	56.02	4.59	0.86	0.99	0.69	0.66
30	56.25	3.66	0.70	1.00	0.57	0.59	30	56.25	3.66	0.68	0.97	0.61	0.58
31	56.48	3.01	0.58	1.00	0.50	0.53	31	56.48	2.88	0.54	0.95	0.54	0.52
32	56.71	1.84	0.35	1.00	0.46	0.48	32	56.71	2.17	0.40	0.92	0.49	0.47
33	57.40	1.75	0.33	0.99	0.36	0.39	33	57.40	1.29	0.24	0.80	0.39	0.38
34	57.86	1.54	0.30	0.99	0.32	0.36	34	57.86	1.12	0.21	0.71	0.35	0.35
35	59.06	1.21	0.23	0.95	0.26	0.30	35	59.06	0.91	0.17	0.48	0.28	0.29
36	61.38	0.87	0.17	0.81	0.19	0.25	36	61.38	0.61	0.11	0.18	0.21	0.23
37	63.67	0.69	0.13	0.62	0.16	0.22	37	63.67	0.46	0.09	0.06	0.17	0.20
38	67.00	0.56	0.11	0.38	0.13	0.19	38	67.00	0.40	0.07	0.01	0.14	0.16
39	69.16	0.52	0.10	0.26	0.12	0.18	39	69.16	0.37	0.07	0.00	0.12	0.15
40	71.32	0.47	0.09	0.18	0.11	0.16	40	71.32	0.35	0.06	0.00	0.11	0.13
41	73.51	0.44	0.08	0.12	0.10	0.15	41	73.51	0.32	0.06	0.00	0.10	0.12
42	75.56	0.40	0.08	0.08	0.09	0.14	42	75.56	0.30	0.06	0.00	0.09	0.11
43	79.91	0.47	0.09	0.03	0.08	0.13	43	79.91	0.31	0.06	0.00	0.08	0.10
44	81.96	0.34	0.06	0.02	0.08	0.12	44	81.96	0.28	0.05	0.00	0.08	0.09
45	84.07	0.35	0.07	0.01	0.07	0.12	45	84.07	0.28	0.05	0.00	0.07	0.08

Table C.7 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.41 mmol/L for Pb2+ and 9.67 mmol/L for Zn2+

	Observed data Pb			Fitted				Observed data Zn			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	0.26	0.00	0.00	0.00	0.00	0.00	1	0.26	0.09	0.01	0.01	0.00	0.00
2	2.47	0.00	0.00	0.04	0.00	0.00	2	1.36	0.12	0.01	0.07	0.00	0.00
3	5.96	0.16	0.03	0.28	0.00	0.00	3	2.47	0.20	0.02	0.22	0.00	0.01
4	7.79	0.68	0.13	0.43	0.00	0.00	4	5.96	3.87	0.40	0.69	0.06	0.44
5	11.57	1.44	0.27	0.68	0.00	0.24	5	7.79	5.68	0.59	0.82	0.64	0.63
6	13.62	2.80	0.52	0.77	0.00	0.58	6	8.95	6.14	0.63	0.88	0.89	0.71
7	16.35	3.30	0.61	0.86	0.61	0.70	7	11.57	6.85	0.71	0.95	0.99	0.81
8	18.16	3.87	0.72	0.92	1.00	0.77	8	13.62	8.12	0.84	0.97	1.00	0.86
9	20.53	4.60	0.85	0.95	1.00	0.82	9	16.35	8.43	0.87	0.99	1.00	0.91
10	22.88	4.84	0.90	0.97	1.00	0.86	10	18.16	9.35	0.97	1.00	1.00	0.94
11	25.49	4.95	0.92	0.98	1.00	0.89	11	20.53	10.31	1.07	1.00	1.00	0.96
12	28.00	4.99	0.92	0.99	1.00	0.92	12	22.88	9.99	1.03	1.00	1.00	0.98
13	30.51	5.25	0.97	0.99	1.00	0.94	13	25.49	10.18	1.05	1.00	1.00	0.99
14	33.06	5.02	0.93	1.00	1.00	0.95	14	28.00	10.10	1.04	1.00	1.00	0.99
15	35.62	5.31	0.98	1.00	1.00	0.96	15	30.51	10.04	1.04	1.00	1.00	0.99
16	38.27	5.37	0.99	1.00	1.00	0.97	16	33.06	9.46	0.98	1.00	1.00	1.00
17	41.21	5.66	1.05	1.00	1.00	0.98	17	35.62	9.57	0.99	1.00	1.00	1.00
18	41.98	5.39	1.00	1.00	1.00	0.98	18	38.27	9.82	1.02	1.00	1.00	1.00
19	42.17	5.19	0.96	1.00	1.00	0.98	19	41.21	9.32	0.96	1.00	1.00	1.00
20	42.37	5.13	0.95	1.00	0.98	0.96	20	41.98	9.47	0.98	1.00	1.00	1.00
21	42.57	5.08	0.94	1.00	0.92	0.90	21	42.17	8.85	0.92	1.00	1.00	1.00
22	42.78	4.92	0.91	1.00	0.83	0.81	22	42.37	9.52	0.98	1.00	0.99	0.98
23	42.97	4.94	0.91	1.00	0.75	0.73	23	42.57	9.25	0.96	1.00	0.97	0.94
24	43.18	4.49	0.83	1.00	0.68	0.66	24	42.78	9.66	1.00	0.99	0.92	0.88

Table C.7 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.41 mmol/L for Pb2+ and 9.67 mmol/L for Zn2+ (Continued)

25	43.58	3.21	0.59	0.99	0.57	0.56	25	42.97	9.47	0.98	0.98	0.86	0.82
26	43.98	1.95	0.36	0.98	0.50	0.49	26	43.18	9.05	0.94	0.97	0.81	0.76
27	45.16	1.35	0.25	0.91	0.37	0.37	27	43.58	6.35	0.66	0.93	0.70	0.66
28	47.05	0.86	0.16	0.69	0.27	0.28	28	43.98	4.45	0.46	0.86	0.62	0.58
29	48.89	0.64	0.12	0.47	0.22	0.24	29	45.16	1.85	0.19	0.61	0.45	0.44
30	50.71	0.49	0.09	0.30	0.19	0.21	30	47.05	1.08	0.11	0.28	0.31	0.32
31	52.66	0.38	0.07	0.18	0.16	0.19	31	48.89	0.86	0.09	0.11	0.23	0.26
32	54.64	0.30	0.06	0.11	0.15	0.17	32	50.71	0.70	0.07	0.04	0.18	0.21
33	57.01	0.28	0.05	0.06	0.13	0.16	33	52.66	0.61	0.06	0.02	0.15	0.18
34	0.00	0.00	0.00	0.00	0.00	0.00	34	54.64	0.56	0.06	0.01	0.12	0.15
35	0.00	0.00	0.00	0.00	0.00	0.00	35	57.01	0.48	0.05	0.00	0.10	0.12
36	0.00	0.00	0.00	0.00	0.00	0.00	36	59.55	0.46	0.05	0.00	0.08	0.10

Table C.8 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.41 mmol/L for Pb2+ and 9.67 mmol/L for Zn2+ (Duplicated)

	Observed data Pb			Fitted				Observed data Zn			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	0.26	0.00	0.00	0.00	0.00	0.00	1	0.26	0.02	0.00	0.00	0.00	0.00
2	1.30	0.00	0.00	0.00	0.00	0.00	2	1.30	0.02	0.00	0.08	0.00	0.00
3	2.62	0.00	0.00	0.04	0.00	0.00	3	2.62	0.24	0.02	0.40	0.00	0.00
4	5.25	0.00	0.00	0.27	0.00	0.00	4	5.25	1.46	0.15	0.85	0.00	0.12
5	7.81	0.29	0.06	0.54	0.00	0.00	5	7.81	4.20	0.44	0.97	0.44	0.54
6	10.34	0.88	0.20	0.74	0.00	0.12	6	10.34	6.09	0.64	0.99	1.00	0.68
7	12.72	1.48	0.33	0.86	0.00	0.44	7	12.72	7.46	0.79	1.00	1.00	0.78
8	15.05	2.05	0.47	0.93	0.00	0.56	8	15.05	7.63	0.80	1.00	1.00	0.84
9	17.28	2.50	0.58	0.96	0.57	0.63	9	17.28	9.06	0.96	1.00	1.00	0.89
10	19.49	2.86	0.66	0.98	1.00	0.70	10	19.49	9.31	0.98	1.00	1.00	0.92
11	21.64	3.15	0.73	0.99	1.00	0.75	11	21.64	8.67	0.91	1.00	1.00	0.94
12	24.91	3.54	0.82	1.00	1.00	0.82	12	24.91	9.94	1.05	1.00	1.00	0.97
13	27.09	3.72	0.86	1.00	1.00	0.85	13	27.09	9.77	1.03	1.00	1.00	0.98
14	29.24	3.88	0.90	1.00	1.00	0.88	14	29.24	10.07	1.06	1.00	1.00	0.98
15	31.40	4.00	0.92	1.00	1.00	0.90	15	31.40	9.56	1.01	1.00	1.00	0.99
16	35.36	4.31	1.00	1.00	1.00	0.92	16	35.36	9.15	0.97	1.00	1.00	0.99
17	37.68	4.26	0.98	1.00	1.00	0.93	17	37.68	9.51	1.00	1.00	1.00	0.99
18	40.01	4.36	1.01	1.00	1.00	0.94	18	40.01	9.36	0.99	1.00	1.00	1.00
19	42.45	4.56	1.05	1.00	1.00	0.95	19	42.45	9.33	0.98	1.00	1.00	1.00
20	44.72	4.49	1.04	1.00	1.00	0.96	20	44.72	9.35	0.99	1.00	1.00	1.00
21	46.31	4.40	1.02	0.99	0.79	0.72	21	46.31	9.21	0.97	0.95	0.75	0.72
22	46.76	3.36	0.77	0.98	0.66	0.58	22	46.76	6.95	0.73	0.85	0.60	0.58
23	47.21	2.19	0.51	0.96	0.56	0.49	23	47.21	4.38	0.46	0.71	0.50	0.48
24	47.68	1.57	0.36	0.93	0.49	0.43	24	47.68	3.12	0.33	0.57	0.43	0.42

Table C.8 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Zinc (Zn2+) transport through lateritic soil under pH 5 with initial concentration 5.41 mmol/L for Pb2+ and 9.67 mmol/L for Zn2+ (Duplicated) (Continued)

25	48.13	1.23	0.28	0.89	0.44	0.39	25	48.13	2.35	0.25	0.45	0.38	0.38
26	48.57	1.05	0.24	0.85	0.40	0.36	26	48.57	1.96	0.21	0.34	0.34	0.35
27	49.02	0.89	0.21	0.80	0.37	0.34	27	49.02	1.79	0.19	0.26	0.31	0.33
28	50.42	0.66	0.15	0.63	0.30	0.29	28	50.42	1.44	0.15	0.10	0.25	0.28
29	54.19	0.30	0.07	0.27	0.22	0.23	29	54.19	0.92	0.10	0.01	0.16	0.21
30	62.58	0.11	0.03	0.03	0.14	0.17	30	62.58	0.62	0.07	0.00	0.10	0.14
31	68.29	0.08	0.02	0.01	0.12	0.15	31	68.29	0.54	0.06	0.00	0.07	0.11
32	73.77	0.06	0.01	0.00	0.10	0.13	32	73.77	0.52	0.05	0.00	0.06	0.09
33	79.23	0.05	0.01	0.00	0.09	0.12	33	79.23	0.48	0.05	0.00	0.05	0.07

Table C.9 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Manganese (Mn2+) transport through lateritic soil under pH 5 with initial concentration 5.31 mmol/L for Pb2+ and 2.73 mmol/L for Mn2+

	Observed data Pb			Fitted				Observed data Mn			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	0.85	0.00	0.00	0.00	0.00	0.00	1	0.85	0.00	0.00	0.00	0.00	0.00
2	2.27	0.00	0.00	0.00	0.00	0.00	2	2.27	0.01	0.00	0.04	0.00	0.00
3	5.11	0.00	0.00	0.06	0.00	0.00	3	5.11	0.16	0.06	0.34	0.00	0.00
4	7.93	0.33	0.06	0.20	0.00	0.00	4	7.93	0.84	0.31	0.65	0.00	0.29
5	10.79	0.86	0.16	0.39	0.00	0.00	5	10.79	1.26	0.46	0.84	0.48	0.59
6	13.66	1.30	0.24	0.55	0.00	0.21	6	13.66	1.62	0.59	0.93	1.00	0.67
7	16.51	2.02	0.38	0.69	0.00	0.47	7	16.51	1.89	0.69	0.97	1.00	0.73
8	19.36	2.56	0.48	0.79	0.00	0.58	8	19.36	2.18	0.80	0.98	1.00	0.78
9	22.22	3.04	0.57	0.86	0.58	0.66	9	22.22	2.34	0.86	0.99	1.00	0.83
10	25.08	3.49	0.66	0.90	1.00	0.72	10	25.08	2.34	0.86	1.00	1.00	0.86
11	29.36	4.52	0.85	0.95	1.00	0.80	11	27.94	2.44	0.89	1.00	1.00	0.89
12	32.21	4.84	0.91	0.97	1.00	0.84	12	29.36	2.47	0.91	1.00	1.00	0.90
13	35.06	4.86	0.91	0.98	1.00	0.87	13	32.21	2.61	0.96	1.00	1.00	0.92
14	37.68	4.95	0.93	0.98	1.00	0.89	14	35.06	2.61	0.96	1.00	1.00	0.93
15	40.51	4.87	0.92	0.99	1.00	0.91	15	37.68	2.62	0.96	1.00	1.00	0.95
16	43.34	5.18	0.98	0.99	1.00	0.93	16	40.51	2.60	0.95	1.00	1.00	0.96
17	46.10	5.14	0.97	1.00	1.00	0.94	17	43.34	2.62	0.96	1.00	1.00	0.96
18	48.87	5.26	0.99	1.00	1.00	0.95	18	46.10	2.62	0.96	1.00	1.00	0.97
19	51.68	5.30	1.00	1.00	1.00	0.96	19	48.87	2.61	0.96	1.00	1.00	0.98
20	54.50	5.35	1.01	1.00	1.00	0.97	20	51.68	2.65	0.97	1.00	1.00	0.98
21	58.66	4.60	0.87	1.00	1.00	0.98	21	55.89	2.63	0.96	1.00	1.00	0.99
22	61.43	5.33	1.00	1.00	1.00	0.98	22	58.66	2.66	0.98	1.00	1.00	0.99
23	64.18	5.24	0.99	1.00	1.00	0.99	23	61.43	2.77	1.01	1.00	1.00	0.99
24	66.95	5.08	0.96	1.00	1.00	0.99	24	64.18	2.76	1.01	1.00	1.00	0.99

Table C.9 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Manganese (Mn2+) transport through lateritic soil under pH 5 with initial concentration 5.31 mmol/L for Pb2+ and 2.73 mmol/L for Mn2+ (Continued)

25	69.77	5.23	0.98	1.00	1.00	0.99	25	66.95	2.66	0.98	1.00	1.00	0.99
26	72.59	5.16	0.97	1.00	1.00	0.99	26	69.77	2.74	1.01	1.00	1.00	1.00
27	75.34	5.09	0.96	1.00	1.00	0.99	27	72.59	2.66	0.97	1.00	1.00	1.00
28	78.15	5.11	0.96	1.00	1.00	0.99	28	75.34	2.68	0.98	1.00	1.00	1.00
29	81.56	5.11	0.96	1.00	1.00	1.00	29	78.15	2.66	0.97	1.00	1.00	1.00
30	81.84	5.06	0.95	1.00	0.99	0.98	30	81.56	2.68	0.98	1.00	1.00	1.00
31	82.13	5.00	0.94	1.00	0.90	0.88	31	81.84	2.63	0.96	1.00	0.98	0.97
32	82.41	4.93	0.93	1.00	0.78	0.76	32	82.13	2.57	0.94	1.00	0.91	0.87
33	82.69	4.43	0.83	1.00	0.68	0.66	33	82.41	2.55	0.93	1.00	0.80	0.75
34	82.96	3.85	0.72	1.00	0.61	0.58	34	82.69	2.34	0.86	1.00	0.70	0.66
35	83.24	3.15	0.59	1.00	0.55	0.52	35	82.96	2.02	0.74	0.99	0.63	0.58
36	83.51	2.10	0.40	1.00	0.50	0.48	36	83.24	1.59	0.58	0.99	0.56	0.53
37	83.79	1.64	0.31	1.00	0.46	0.44	37	83.51	1.26	0.46	0.97	0.51	0.48
38	85.22	1.16	0.22	0.98	0.34	0.34	38	83.79	0.98	0.36	0.96	0.47	0.45
39	88.08	0.71	0.13	0.88	0.24	0.27	39	85.22	0.54	0.20	0.83	0.35	0.34
40	90.93	0.69	0.13	0.71	0.20	0.23	40	88.08	0.33	0.12	0.48	0.24	0.26
41	93.78	0.57	0.11	0.53	0.17	0.21	41	90.93	0.28	0.10	0.24	0.19	0.22
42	96.63	0.57	0.11	0.37	0.15	0.19	42	93.78	0.23	0.08	0.11	0.16	0.20
43	99.46	0.49	0.09	0.26	0.13	0.18	43	96.63	0.22	0.08	0.05	0.14	0.18
44	102.29	0.42	0.08	0.18	0.12	0.17	44	99.46	0.19	0.07	0.02	0.12	0.16
45	105.11	0.42	0.08	0.12	0.11	0.16	45	102.29	0.17	0.06	0.01	0.11	0.15
46	109.32	0.39	0.07	0.06	0.10	0.14	46	105.11	0.16	0.06	0.00	0.10	0.14
47	112.11	0.39	0.07	0.04	0.10	0.14	47	109.32	0.14	0.05	0.00	0.09	0.13
48	116.28	0.20	0.04	0.02	0.09	0.13	48	112.11	0.13	0.05	0.00	0.08	0.12
							49	114.89	0.07	0.03	0.00	0.07	0.11

Table C.10 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Manganese (Mn2+) transport through lateritic soil under pH 5 with initial concentration 5.14 mmol/L for Pb2+ and 4.47 mmol/L for Mn2+

	Observed data Pb			Fitted				Observed data Mn			Fitted		
Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0	Sample #	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	0.98	0.00	0.00	0.00	0.00	0.00	1	0.98	0.00	0.00	0.00	0.00	0.00
2	4.46	0.01	0.00	0.06	0.00	0.00	2	1.92	0.01	0.00	0.03	0.00	0.00
3	6.93	0.16	0.03	0.22	0.00	0.00	3	4.46	0.26	0.06	0.31	0.00	0.00
4	9.33	0.59	0.11	0.41	0.00	0.00	4	6.93	1.26	0.28	0.63	0.00	0.26
5	11.74	0.97	0.19	0.58	0.00	0.01	5	9.33	2.14	0.48	0.83	0.00	0.63
6	14.23	2.04	0.40	0.72	0.05	0.39	6	11.74	2.89	0.65	0.92	0.67	0.75
7	16.70	2.69	0.52	0.81	0.90	0.62	7	14.23	3.53	0.79	0.97	1.00	0.83
8	19.19	3.18	0.62	0.88	0.99	0.71	8	16.70	4.12	0.92	0.98	1.00	0.88
9	21.66	3.55	0.69	0.92	1.00	0.79	9	19.19	4.19	0.94	0.99	1.00	0.92
10	25.42	4.62	0.90	0.96	1.00	0.86	10	21.66	4.35	0.97	1.00	1.00	0.94
11	27.93	4.78	0.93	0.97	1.00	0.90	11	25.42	4.37	0.98	1.00	1.00	0.96
12	30.47	5.03	0.98	0.98	1.00	0.92	12	27.93	4.38	0.98	1.00	1.00	0.97
13	33.02	5.00	0.97	0.99	1.00	0.94	13	30.47	4.31	0.96	1.00	1.00	0.98
14	35.56	5.22	1.02	0.99	1.00	0.96	14	33.02	4.41	0.99	1.00	1.00	0.98
15	38.13	5.08	0.99	1.00	1.00	0.97	15	35.56	4.33	0.97	1.00	1.00	0.99
16	40.69	5.25	1.02	1.00	1.00	0.97	16	38.13	4.42	0.99	1.00	1.00	0.99
17	43.27	5.28	1.03	1.00	1.00	0.98	17	40.69	4.40	0.98	1.00	1.00	0.99
18	45.80	5.26	1.02	1.00	1.00	0.99	18	43.27	4.54	1.02	1.00	1.00	1.00
19	48.38	5.29	1.03	1.00	1.00	0.99	19	45.80	4.55	1.02	1.00	1.00	1.00
20	49.67	5.34	1.04	1.00	1.00	0.99	20	48.38	4.49	1.00	1.00	1.00	1.00
21	52.26	5.16	1.00	1.00	1.00	0.99	21	49.67	4.52	1.01	1.00	1.00	1.00
22	54.88	5.13	1.00	1.00	1.00	0.99	22	52.26	4.49	1.00	1.00	1.00	1.00
23	57.52	5.15	1.00	1.00	1.00	1.00	23	54.88	4.68	1.05	1.00	1.00	1.00
24	60.18	5.05	0.98	1.00	1.00	1.00	24	57.52	4.82	1.08	1.00	1.00	1.00

Table C.10 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Manganese (Mn2+) transport through lateritic soil under pH 5 with initial concentration 5.14 mmol/L for Pb2+ and 4.47 mmol/L for Mn2+ (Continued)

25	62.89	5.14	1.00	1.00	1.00	1.00	25	60.18	4.73	1.06	1.00	1.00	1.00
26	65.64	5.09	0.99	1.00	1.00	1.00	26	62.89	4.69	1.05	1.00	1.00	1.00
27	68.40	5.10	0.99	1.00	1.00	1.00	27	65.64	4.51	1.01	1.00	1.00	1.00
28	71.10	4.87	0.95	1.00	1.00	1.00	28	68.40	4.42	0.99	1.00	1.00	1.00
29	73.78	4.88	0.95	1.00	1.00	1.00	29	71.10	4.43	0.99	1.00	1.00	1.00
30	74.05	5.03	0.98	1.00	1.00	1.00	30	73.78	4.25	0.95	1.00	1.00	1.00
31	74.32	5.18	1.01	1.00	1.00	0.99	31	74.05	4.28	0.96	1.00	1.00	1.00
32	74.59	5.24	1.02	1.00	0.98	0.93	32	74.32	4.39	0.98	1.00	0.99	0.98
33	74.86	4.20	0.82	1.00	0.96	0.83	33	74.59	4.38	0.98	1.00	0.94	0.91
34	75.12	4.70	0.92	1.00	0.91	0.74	34	74.86	4.27	0.95	1.00	0.85	0.82
35	75.39	4.67	0.91	1.00	0.87	0.67	35	75.12	4.23	0.95	1.00	0.76	0.73
36	75.66	3.63	0.71	1.00	0.82	0.60	36	75.39	3.89	0.87	0.99	0.69	0.66
37	75.94	2.56	0.50	1.00	0.77	0.56	37	75.66	3.11	0.70	0.98	0.62	0.60
38	76.20	2.43	0.47	1.00	0.73	0.52	38	75.94	2.44	0.54	0.97	0.57	0.55
39	76.46	1.95	0.38	1.00	0.69	0.48	39	76.20	1.90	0.42	0.96	0.52	0.51
40	79.00	0.92	0.18	0.92	0.46	0.33	40	76.46	1.54	0.34	0.94	0.49	0.48
41	81.58	0.69	0.13	0.74	0.35	0.27	41	79.00	0.64	0.14	0.61	0.30	0.32
42	84.09	0.60	0.12	0.55	0.29	0.23	42	81.58	0.44	0.10	0.32	0.23	0.26
43	86.55	0.56	0.11	0.39	0.25	0.21	43	84.09	0.40	0.09	0.15	0.19	0.22
44	90.28	0.48	0.09	0.21	0.20	0.18	44	86.55	0.35	0.08	0.07	0.16	0.19
45	92.81	0.44	0.09	0.14	0.18	0.17	45	90.28	0.30	0.07	0.02	0.13	0.16
46	95.31	0.46	0.09	0.09	0.17	0.16	46	92.81	0.27	0.06	0.01	0.12	0.14
47	97.75	0.41	0.08	0.06	0.15	0.15	47	95.31	0.25	0.06	0.00	0.11	0.13
48	100.20	0.40	0.08	0.04	0.14	0.14	48	97.75	0.24	0.05	0.00	0.10	0.12
49	102.60	0.36	0.07	0.02	0.13	0.13	49	100.20	0.22	0.05	0.00	0.09	0.11
50	107.30	0.36	0.07	0.01	0.11	0.12	50	102.60	0.20	0.05	0.00	0.09	0.10
51	109.78	0.26	0.05	0.01	0.10	0.11	51	107.30	0.17	0.04	0.00	0.08	0.08
52							52	109.78	0.13	0.03	0.00	0.07	0.08

Table C.11 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Manganese (Mn2+) transport through lateritic soil under pH 5 with initial concentration 4.85 mmol/L for Pb2+ and 8.66 mmol/L for Mn2+

Sample #	Observed data Pb			Fitted			Sample #	Observed data Mn			Fitted		
	Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0		Pore volume	Conc.(mM)	C/C0	Linear C/C0	Langmuir C/C0	TSM C/C0
1	0.57	0.00	0.00	0.00	0.00	0.00	1	0.57	0.00	0.00	0.01	0.00	0.00
2	2.41	0.00	0.00	0.02	0.00	0.00	2	2.41	0.00	0.00	0.24	0.00	0.00
3	4.92	0.00	0.00	0.14	0.00	0.00	3	4.92	69.69	0.15	0.71	0.15	0.09
4	7.48	0.46	0.09	0.35	0.00	0.00	4	7.48	188.58	0.40	0.91	1.00	0.54
5	9.95	1.09	0.21	0.55	0.00	0.16	5	9.95	271.14	0.57	0.97	1.00	0.65
6	12.37	1.60	0.31	0.71	0.00	0.44	6	12.37	326.40	0.69	0.99	1.00	0.73
7	14.90	2.17	0.42	0.82	0.44	0.57	7	14.90	373.80	0.79	1.00	1.00	0.80
8	17.42	2.79	0.54	0.89	1.00	0.67	8	17.42	412.80	0.87	1.00	1.00	0.85
9	20.54	3.43	0.67	0.93	1.00	0.74	9	20.54	435.00	0.91	1.00	1.00	0.88
10	23.48	3.85	0.75	0.96	1.00	0.80	10	23.48	445.50	0.94	1.00	1.00	0.91
11	25.94	4.11	0.80	0.97	1.00	0.85	11	25.94	444.00	0.93	1.00	1.00	0.93
12	27.15	4.10	0.80	0.98	1.00	0.87	12	27.15	435.00	0.91	1.00	1.00	0.94
13	29.76	4.44	0.87	0.99	1.00	0.90	13	29.76	447.60	0.94	1.00	1.00	0.96
14	32.31	4.62	0.90	0.99	1.00	0.92	14	32.31	456.90	0.96	1.00	1.00	0.97
15	34.88	4.79	0.94	1.00	1.00	0.94	15	34.88	462.90	0.97	1.00	1.00	0.97
16	37.52	4.71	0.92	1.00	1.00	0.95	16	37.52	458.10	0.96	1.00	1.00	0.98
17	40.14	4.94	0.96	1.00	1.00	0.96	17	40.14	466.80	0.98	1.00	1.00	0.99
18	42.78	5.08	0.99	1.00	1.00	0.97	18	42.78	466.20	0.98	1.00	1.00	0.99
19	45.43	5.22	1.02	1.00	1.00	0.98	19	45.43	485.70	1.02	1.00	1.00	0.99
20	48.04	5.16	1.01	1.00	1.00	0.98	20	48.04	493.20	1.04	1.00	1.00	0.99
21	51.95	5.16	1.01	1.00	1.00	0.99	21	51.95	484.80	1.02	1.00	1.00	1.00
22	54.82	5.14	1.00	1.00	1.00	0.99	22	54.82	488.40	1.03	1.00	1.00	1.00
23	57.38	5.24	1.02	1.00	1.00	0.99	23	57.38	486.30	1.02	1.00	1.00	1.00
24	59.96	5.15	1.01	1.00	1.00	1.00	24	59.96	492.30	1.03	1.00	1.00	1.00

Table C.11 Observed, predicted and simulated breakthrough curves of Lead (Pb2+) and Manganese (Mn2+) transport through lateritic soil under pH 5 with initial concentration 4.85 mmol/L for Pb2+ and 8.66 mmol/L for Mn2+ (Continued)

25	62.56	5.18	1.01	1.00	1.00	1.00	25	62.56	496.20	1.04	1.00	1.00	1.00
26	65.17	5.17	1.01	1.00	1.00	1.00	26	65.17	488.40	1.03	1.00	1.00	1.00
27	67.77	5.05	0.99	1.00	1.00	1.00	27	67.77	489.60	1.07	1.00	1.00	1.00
28	70.37	5.21	1.02	1.00	1.00	1.00	28	70.37	488.40	1.07	1.00	1.00	1.00
29	72.72	5.26	1.03	1.00	1.00	1.00	29	72.72	472.50	1.04	1.00	1.00	1.00
30	75.34	5.04	0.98	1.00	1.00	1.00	30	75.34	482.10	1.06	1.00	1.00	1.00
31	77.42	5.03	0.98	1.00	1.00	1.00	31	77.42	484.80	1.06	1.00	1.00	1.00
32	78.11	4.91	0.96	1.00	0.90	0.90	32	78.11	478.80	1.05	1.00	0.87	0.84
33	78.86	4.79	0.94	1.00	0.68	0.68	33	78.86	389.10	0.85	0.98	0.62	0.58
34	79.23	3.68	0.72	1.00	0.61	0.60	34	79.23	298.95	0.66	0.96	0.54	0.51
35	79.52	2.82	0.55	1.00	0.54	0.55	35	79.52	218.76	0.48	0.93	0.47	0.45
36	79.77	2.38	0.46	1.00	0.49	0.50	36	79.77	174.75	0.38	0.89	0.43	0.41
37	80.03	1.98	0.39	0.99	0.46	0.47	37	80.03	157.41	0.35	0.85	0.39	0.38
38	80.29	1.75	0.34	0.99	0.42	0.44	38	80.29	131.58	0.29	0.81	0.36	0.35
39	80.56	1.55	0.30	0.99	0.40	0.42	39	80.56	106.17	0.23	0.75	0.33	0.33
40	81.08	1.26	0.25	0.97	0.35	0.38	40	81.08	88.17	0.19	0.65	0.29	0.30
41	83.72	0.69	0.13	0.82	0.24	0.29	41	83.72	47.49	0.10	0.24	0.19	0.23
42	86.30	0.53	0.10	0.60	0.19	0.25	42	86.30	35.40	0.08	0.07	0.14	0.20
43	88.98	0.54	0.11	0.41	0.16	0.23	43	88.98	31.74	0.07	0.02	0.11	0.17
44	91.63	0.40	0.08	0.26	0.14	0.21	44	91.63	26.95	0.06	0.01	0.09	0.16
45	94.28	0.39	0.08	0.17	0.13	0.19	45	94.28	33.03	0.07	0.00	0.08	0.14
46	96.91	0.23	0.04	0.10	0.12	0.18	46	96.91	22.46	0.05	0.00	0.07	0.13
47	100.77	0.21	0.04	0.05	0.10	0.16	47	100.77	19.59	0.04	0.00	0.06	0.12
48	103.24	0.27	0.05	0.03	0.10	0.15	48	103.24	19.70	0.04	0.00	0.05	0.11
49	105.63	0.27	0.05	0.02	0.09	0.14	49	105.63	24.59	0.05	0.00	0.05	0.10
50	107.85	0.23	0.04	0.01	0.08	0.13	50	107.85	18.38	0.04	0.00	0.04	0.09
51	110.02	0.22	0.04	0.01	0.08	0.13	51	110.02	17.26	0.04	0.00	0.04	0.09
52	111.96	0.24	0.05	0.00	0.08	0.12	52	111.96	17.16	0.04	0.00	0.04	0.08

APPENDIX D *t*-test results for the average SSEs obtaining from the chemical nonequilibrium two-site model and convection-dispersion model with Langmuir model of single metal, binary, and multi-metal systems

Table D.1 *t*-test for SSE of single metal system at pH 4

	Test Value = 0.139					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	-11.689	4	.000	-.0984	-.1218	-.0750

Table D.2 *t*-test for SSE of single metal system at pH 5

	Test Value = 0.0408					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	5.046	4	.007	.1398	.0629	.2167

Table D.3 *t*-test for SSE of Pb^{2+} in Pb^{2+} -Ni^{2+} system

	Test Value = 0.03075					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	7.078	3	.006	.0843	.0464	.1221

Table D.4 *t*-test for SSE of Ni^{2+} in Pb^{2+} -Ni^{2+} system

	Test Value = 0.035					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	5.800	3	.010	.0725	.0327	.1123

Table D.5 *t*-test for SSE of Pb^{2+} in Pb^{2+} -Zn^{2+} system

	Test Value = 0.046					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	3.963	3	.029	.0815	.0161	.1469

Table D.6 *t*-test for SSE of Zn^{2+} in Pb^{2+} -Zn^{2+} system

	Test Value = 0.04					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	3.806	3	.032	.0325	.0053	.0597

Table D.7 *t*-test for SSE of Pb^{2+} in Pb^{2+} - Mn^{2+} system

	Test Value = 0.03933					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	12.240	2	.007	.0707	.0458	.0955

Table D.8 *t*-test for SSE of Mn^{2+} in Pb^{2+} - Mn^{2+} system

	Test Value = 0.0333					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	5.673	2	.030	.0500	.0121	.0880

Table D.9 *t*-test for SSE of multi-metal system

	Test Value = 0.04					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EQUIL	5.166	3	.014	.0325	.0125	.0525

BIOGRAPHY

Srilert Chotpantarat was born on 6 January 1977, in the Songkhla province. He received a bachelor's degree in Civil Engineering in 1997 from the Faculty of Engineering, Chulalongkorn University and a master's degree in Water Resources Engineering in 2002 from the Faculty of Engineering, Chulalongkorn University. He was awarded a scholarship by the Geology Department, Faculty of Science, Chulalongkorn University in 2001. He enrolled in the International Post-graduate Program in Environmental Management, National Center of Excellence for Environmental and Hazardous Waste Management, Chulalongkorn University in 2004 and completed his Doctor of Philosophy in Environmental Management in 2008.