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APPENDICES

Appendix A

Effect of Contact Time on Removal Efficiency

Table A-1 Removal of Pb at difference contact time by bagasse (Bagasse dose 10 g/L, Volume of sample 50 mL, Shaking speed 125 rpm, and room temperature)

Contact time (min)	Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
			No material		Add material				
	Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
0	10.020	4.12	10.020 ± 0.003	4.12	10.020 ± 0.002	4.12	0.00	0.00	0.00
3	10.020	4.12	9.987 ± 0.054	4.12	5.204 ± 0.056	3.97	48.06	0.33	48.39
6	10.020	4.12	9.999 ± 0.064	4.12	5.495 ± 0.070	3.96	45.16	0.22	45.38
9	10.020	4.12	9.997 ± 0.055	4.12	5.071 ± 0.067	3.96	49.38	0.23	49.62
12	10.020	4.12	9.995 ± 0.015	4.12	5.008 ± 0.048	3.97	50.02	0.25	50.27
15	10.020	4.12	9.993 ± 0.054	4.12	3.326 ± 0.058	3.95	66.81	0.27	67.08
30	10.020	4.12	9.997 ± 0.032	4.12	3.510 ± 0.053	3.94	64.97	0.23	65.20
45	10.020	4.12	9.994 ± 0.011	4.12	3.077 ± 0.477	3.95	69.29	0.26	69.55
60	10.020	4.12	9.997 ± 0.048	4.12	3.389 ± 0.033	3.95	66.18	0.23	66.41
90	10.020	4.12	9.996 ± 0.025	4.12	3.349 ± 0.017	3.94	66.58	0.24	66.82
120	10.020	4.12	9.993 ± 0.036	4.12	3.465 ± 0.028	3.89	65.43	0.27	65.69
150	10.020	4.12	9.996 ± 0.042	4.12	3.462 ± 0.044	3.89	65.46	0.24	65.69
180	10.020	4.12	9.994 ± 0.026	4.12	3.106 ± 0.326	3.90	68.99	0.26	69.26
240	10.020	4.12	9.997 ± 0.041	4.12	3.356 ± 0.099	3.87	66.51	0.23	66.74
300	10.020	4.12	9.997 ± 0.023	4.12	3.383 ± 0.067	3.88	66.24	0.23	66.47
360	10.020	4.12	9.998 ± 0.017	4.12	3.586 ± 0.048	3.88	64.21	0.22	64.43

Table A-2 Removal of Pb at difference contact time by bagasse fly ash (Bagasse Fly Ash dose 10 g/L, Volume of sample 50 mL, Shaking speed 125 rpm, and room temperature)

Contact time (min)	Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
			No material		Add material				
	Conc. (mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
0	10.013	4.00	10.013 ± 0.003	4.00	10.013 ± 0.002	4.00	0.00	0.00	0.00
3	10.013	4.00	9.999 ± 0.014	4.00	1.121 ± 0.058	4.15	88.79	0.14	88.94
6	10.013	4.00	9.987 ± 0.014	4.00	0.878 ± 0.119	4.14	91.23	0.26	91.49
9	10.013	4.00	9.985± 0.015	4.00	0.857 ± 0.073	4.15	91.44	0.28	91.72
12	10.013	4.00	9.974 ± 0.015	4.00	0.687 ± 0.152	4.15	93.13	0.39	93.53
15	10.013	4.00	9.940 ± 0.024	4.00	0.819 ± 0.045	4.16	91.82	0.73	92.55
30	10.013	4.00	9.971 ± 0.012	4.00	0.722 ± 0.153	4.19	92.79	0.42	93.21
45	10.013	4.00	9.983 ± 0.011	4.00	0.360 ± 0.055	4.21	96.40	0.30	96.70
60	10.013	4.00	9.965 ± 0.028	4.00	0.480 ± 0.120	4.22	95.21	0.48	95.69
90	10.013	4.00	9.924 ± 0.015	4.00	0.476 ± 0.159	4.22	95.25	0.89	96.14
120	10.013	4.00	9.636 ± 0.026	4.00	0.734 ± 0.020	4.23	92.66	3.77	96.44
150	10.013	4.00	9.895 ± 0.012	4.00	0.504 ± 0.138	4.22	94.97	1.18	96.15
180	10.013	4.00	9.911 ± 0.016	4.00	0.458 ± 0.077	4.24	95.42	1.02	96.45
240	10.013	4.00	9.901 ± 0.011	4.00	0.465 ± 0.053	4.25	95.36	1.12	96.48
300	10.013	4.00	9.886 ± 0.023	4.00	0.424 ± 0.033	4.24	95.78	1.27	97.04
360	10.013	4.00	9.847 ± 0.015	4.00	0.568 ± 0.095	4.27	94.34	1.66	95.99

Table A-3 Removal of Cr at difference contact time by bagasse (Bagasse dose 20 g/L, Volume of sample 50 mL, Shaking speed 125 rpm, and room temperature)

Contact time (min)	Initial properties of solution		Final properties of solution					% Removal of Cr(VI)	% Removal of Total Cr
			No material		Add material				
	Cr(VI) Conc. (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
0	10.441	2.00	10.441 ± 0.001	2.00	10.441 ± 0.002	10.441 ± 0.002	2.00	0.00	0.00
3	10.441	2.00	10.439 ± 0.002	2.00	10.441 ± 0.004	10.441 ± 0.003	2.06	0.00	0.00
6	10.441	2.00	10.440 ± 0.001	2.00	9.261 ± 0.045	10.242 ± 0.024	2.05	11.30	1.92
9	10.441	2.00	10.439 ± 0.001	2.00	8.062 ± 0.014	9.921 ± 0.012	2.06	22.79	4.98
12	10.441	2.00	10.439 ± 0.002	2.00	6.951 ± 0.120	9.492 ± 0.024	2.10	33.43	9.09
15	10.441	2.00	10.439 ± 0.001	2.00	3.571 ± 0.045	8.865 ± 0.042	2.07	65.80	15.09
30	10.441	2.00	10.439 ± 0.003	2.00	ND	8.751 ± 0.012	2.05	100.00	16.19
45	10.441	2.00	10.440 ± 0.001	2.00	ND	8.734 ± 0.033	2.05	100.00	16.35
60	10.441	2.00	10.440 ± 0.001	2.00	ND	8.784 ± 0.047	2.04	100.00	15.87
90	10.441	2.00	10.439 ± 0.002	2.00	ND	8.739 ± 0.026	2.06	100.00	16.30
120	10.441	2.00	10.440 ± 0.001	2.00	ND	8.745 ± 0.045	2.10	100.00	16.24
150	10.441	2.00	10.439 ± 0.001	2.00	ND	8.789 ± 0.014	2.06	100.00	15.82
180	10.441	2.00	10.439 ± 0.002	2.00	ND	8.720 ± 0.036	2.02	100.00	16.48
240	10.441	2.00	10.439 ± 0.003	2.00	ND	8.673 ± 0.085	2.03	100.00	16.93
300	10.441	2.00	10.439 ± 0.001	2.00	ND	8.659 ± 0.025	2.02	100.00	17.07
360	10.441	2.00	10.440 ± 0.001	2.00	ND	8.657 ± 0.015	2.05	100.00	17.09

ND referred to non detection (less than detection limit of equipment)

Table A-4 Removal of Cr at difference contact time by bagasse fly ash (Bagasse Fly Ash dose 20 g/L, Volume of sample 50 mL, Shaking speed 125 rpm, and room temperature)

Contact time (min)	Initial properties of solution		Final properties of solution					% Removal of Cr(VI)	% Removal of Total Cr
			No material		Add material				
	Cr(VI) (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
0	9.029	2.00	9.029 ± 0.001	2.00	9.209 ± 0.002	9.029 ± 0.005	2.00	0.00	0.00
3	9.029	2.00	9.028 ± 0.002	2.00	9.209 ± 0.001	9.029 ± 0.003	2.06	0.00	0.00
6	9.029	2.00	9.029 ± 0.003	2.00	6.148 ± 0.012	6.373 ± 0.012	2.05	31.91	29.42
9	9.029	2.00	9.028 ± 0.001	2.00	5.473 ± 0.025	6.150 ± 0.023	2.03	39.38	31.89
12	9.029	2.00	9.029 ± 0.005	2.00	5.259 ± 0.036	6.220 ± 0.033	2.10	41.75	31.11
15	9.029	2.00	9.029 ± 0.006	2.00	4.556 ± 0.069	5.752 ± 0.045	2.07	49.54	36.29
30	9.029	2.00	9.028 ± 0.004	2.00	2.818 ± 0.058	4.435 ± 0.056	2.04	68.79	50.88
45	9.029	2.00	9.029 ± 0.002	2.00	2.837 ± 0.069	4.464 ± 0.067	2.06	68.58	50.56
60	9.029	2.00	9.029 ± 0.003	2.00	2.776 ± 0.077	4.364 ± 0.069	2.04	69.26	51.67
90	9.029	2.00	9.029 ± 0.003	2.00	2.605 ± 0.089	4.203 ± 0.098	2.06	71.15	53.45
120	9.029	2.00	9.028 ± 0.001	2.00	2.648 ± 0.102	4.208 ± 0.103	2.09	70.67	53.40
150	9.029	2.00	9.029 ± 0.005	2.00	2.527 ± 0.056	4.050 ± 0.016	2.07	72.01	55.14
180	9.029	2.00	9.028 ± 0.003	2.00	2.525 ± 0.091	4.129 ± 0.096	2.02	72.03	54.27
240	9.029	2.00	9.028 ± 0.004	2.00	2.450 ± 0.069	4.031 ± 0.064	2.02	72.86	55.36
300	9.029	2.00	9.029 ± 0.002	2.00	2.430 ± 0.057	3.952 ± 0.069	2.06	73.09	56.23
360	9.029	2.00	9.029 ± 0.002	2.00	2.459 ± 0.045	3.962 ± 0.066	2.05	72.76	56.12

Appendix B

Effect of Initial Concentration and Solution pH on Removal Efficiency

Table B-1 Removal of Pb at different initial concentration and solution pH by bagasse (Bagasse dose 10 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature)

Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
		No adsorbent		Add adsorbent				
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
4.916	1.02	4.912 ± 0.025	1.02	4.889 ± 0.125	1.01	0.55	0.08	0.63
4.916	2.05	4.911 ± 0.034	2.05	4.786 ± 0.214	2.03	2.65	0.11	2.76
4.916	3.04	4.910 ± 0.037	3.04	3.358 ± 0.116	2.99	31.69	0.12	31.82
4.916	4.06	4.906 ± 0.047	4.06	1.737 ± 0.145	3.90	64.66	0.20	64.86
4.916	5.05	4.894 ± 0.046	5.05	1.040 ± 0.213	4.85	78.84	0.43	79.27
4.916	6.03	4.894 ± 0.054	6.03	0.237 ± 0.178	5.40	95.18	0.45	95.63
10.610	1.01	10.602 ± 0.078	1.01	10.434 ± 0.199	1.02	1.67	0.08	1.74
10.610	2.03	10.602 ± 0.004	2.03	10.319 ± 0.246	2.00	2.74	0.08	2.82
10.610	3.16	10.596 ± 0.075	3.16	7.216 ± 0.178	3.00	31.98	0.13	32.12
10.610	4.04	10.588 ± 0.019	4.04	5.299 ± 0.121	3.90	50.06	0.21	50.27
10.610	5.03	10.562 ± 0.047	5.03	2.481 ± 0.214	4.89	76.62	0.45	77.07
10.610	5.97	10.561 ± 0.069	5.97	1.856 ± 0.124	5.45	82.52	0.46	82.97
20.508	1.02	20.496 ± 0.099	1.02	20.157 ± 0.284	1.03	1.71	0.06	1.77
20.508	2.08	20.484 ± 0.140	2.08	19.962 ± 0.141	2.03	2.66	0.12	2.78
20.508	3.04	20.481 ± 0.084	3.04	17.865 ± 0.212	2.99	12.89	0.13	13.02
20.508	4.05	20.463 ± 0.036	4.05	13.133 ± 0.209	3.89	35.96	0.22	36.18
20.508	5.03	20.418 ± 0.031	5.03	7.395 ± 0.114	4.86	63.94	0.44	64.38
20.508	6.03	20.408 ± 0.029	6.03	4.573 ± 0.214	5.41	77.71	0.49	78.19

Table B-1 (cont)

Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
		No adsorbent		Add adsorbent				
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
30.125	1.02	30.111 ± 0.048	1.02	29.580 ± 0.102	1.01	1.82	0.05	1.86
30.125	2.02	30.081 ± 0.056	2.02	29.269 ± 0.114	1.95	2.85	0.15	2.99
30.125	3.00	30.069 ± 0.078	3.00	27.179 ± 0.147	3.02	9.78	0.19	9.97
30.125	4.01	30.061 ± 0.052	4.01	21.075 ± 0.158	3.99	30.04	0.21	30.25
30.125	5.06	29.898 ± 0.066	5.06	13.484 ± 0.126	5.04	55.24	0.45	55.69
30.125	6.04	29.971 ± 0.074	6.04	8.396 ± 0.177	6.01	72.13	0.51	72.64
41.130	1.05	41.052 ± 0.044	1.05	40.077 ± 0.212	0.99	2.56	0.19	2.75
41.130	2.03	41.044 ± 0.085	2.03	39.929 ± 0.211	2.00	2.92	0.21	3.13
41.130	3.04	41.035 ± 0.014	3.04	37.947 ± 0.196	2.99	7.74	0.23	7.97
41.130	4.05	41.027 ± 0.007	4.05	29.334 ± 0.214	3.89	28.68	0.25	28.93
41.130	5.01	40.941 ± 0.003	5.01	20.429 ± 0.3 07	4.89	50.33	0.46	50.79
41.130	6.03	40.916 ± 0.102	6.03	13.256 ± 0.108	5.81	67.77	0.52	68.29
80.620	1.02	80.418 ± 0.009	1.02	78.846 ± 0.197	0.98	2.19	0.25	2.45
80.620	2.02	80.410 ± 0.047	2.02	77.919 ± 0.124	2.00	3.35	0.26	3.61
80.620	3.01	80.410 ± 0.034	3.01	72.171 ± 0.134	3.00	10.48	0.26	10.74
80.620	4.03	80.370 ± 0.078	4.03	66.052 ± 0.214	3.90	18.07	0.31	18.38
80.620	5.03	80.209 ± 0.064	5.03	49.501 ± 0.211	4.96	38.60	0.51	39.11
80.620	6.02	80.120 ± 0.066	6.02	27.669 ± 0.201	5.59	65.68	0.62	66.30

Table B-2 Removal of Pb at difference initial concentration and solution pH by bagasse fly ash (Bagasse fly ash dose 10 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature)

Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
		No adsorbent		Add adsorbent				
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
5.448	1.02	5.445 ± 0.036	1.02	0.424 ± 0.103	1.06	92.22	0.06	92.27
5.448	2.02	5.441 ± 0.075	2.02	0.282 ± 0.115	2.09	94.82	0.13	94.95
5.448	3.01	5.438 ± 0.069	3.01	ND	3.17	ND	0.18	ND
5.448	4.02	5.433 ± 0.055	4.02	ND	4.14	ND	0.28	ND
5.448	5.01	5.408 ± 0.047	5.01	ND	5.13	ND	0.73	ND
5.448	6.00	5.387 ± 0.059	6.00	ND	6.18	ND	1.12	ND
11.980	1.05	11.975 ± 0.087	1.05	1.799 ± 0.210	1.07	84.98	0.04	85.02
11.980	2.00	11.960 ± 0.089	2.00	1.495 ± 0.109	2.16	87.53	0.17	87.69
11.980	3.00	11.952 ± 0.056	3.00	0.809 ± 0.165	3.15	93.25	0.23	93.48
11.980	4.03	11.968 ± 0.064	4.03	0.267 ± 0.114	4.12	97.77	0.10	97.87
11.980	5.02	11.909 ± 0.047	5.02	ND	5.17	ND	0.59	ND
11.980	6.02	11.866 ± 0.099	6.02	ND	6.10	ND	0.95	ND
20.030	1.02	20.000 ± 0.054	1.02	5.154 ± 0.114	1.11	74.27	0.15	74.42
20.030	2.01	19.997 ±0.012	2.01	4.791 ± 0.204	2.12	76.09	0.17	76.25
20.030	3.00	20.003 ± 0.054	3.00	1.442 ± 0.215	3.18	92.81	0.14	92.94
20.030	4.01	19.989 ±0.055	4.01	0.709 ± 0.118	4.16	96.46	0.21	96.67
20.030	5.03	19.860 ± 0.069	5.03	0.443 ± 0.168	5.17	97.79	0.85	98.64
20.030	6.01	19.810 ± 0.087	6.01	0.310 ± 0.147	6.13	98.44	1.09	99.54

Table B-2 (cont)

Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
		No adsorbent		Add adsorbent				
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
30.055	1.02	30.016 ± 0.035	1.02	10.492 ± 0.127	1.07	65.09	0.13	65.22
30.055	2.02	30.001 ± 0.024	2.02	9.134 ± 0.136	2.07	69.61	0.18	69.79
30.055	3.01	29.998 ± 0.024	3.01	2.762 ± 0.201	3.15	90.81	0.19	91.00
30.055	4.00	29.980 ± 0.045	4.00	1.274 ± 0.205	4.16	95.77	0.25	96.01
30.055	5.05	29.807 ± 0.055	5.05	0.817 ± 0.224	5.14	97.29	0.83	98.11
30.055	6.04	29.697 ± 0.068	6.04	0.586 ± 0.109	6.12	98.05	1.19	99.24
43.130	1.01	43.075 ± 0.047	1.01	19.702 ± 0.117	1.12	54.32	0.13	54.45
43.130	2.02	43.022 ± 0.068	2.02	17.252 ± 0.213	2.08	60.01	0.25	60.25
43.130	3.02	43.070 ± 0.057	3.02	4.425 ± 0.223	3.11	89.74	0.14	89.88
43.130	4.03	43.035 ± 0.047	4.03	1.988 ± 0.301	4.09	95.39	0.22	95.61
43.130	5.00	42.785 ± 0.085	5.00	1.389 ± 0.209	5.15	96.78	0.80	97.58
43.130	6.01	42.535 ± 0.068	6.01	1.061 ± 0.118	6.18	97.55	1.38	98.92
80.620	1.00	80.547 ± 0.047	1.00	62.384 ± 0.106	1.21	22.62	0.09	22.71
80.620	2.02	80.483 ± 0.088	2.02	58.127 ± 0.147	2.14	27.89	0.17	28.07
80.620	3.01	80.394 ± 0.097	3.01	13.544 ± 0.145	3.14	83.19	0.28	83.48
80.620	4.00	80.427 ± 0.054	4.00	8.804 ± 0.112	4.12	89.08	0.24	89.32
80.620	5.04	79.983 ± 0.098	5.04	3.918 ± 0.204	5.17	95.14	0.79	95.93
80.620	6.03	79.588 ± 0.066	6.03	1.467 ± 0.226	6.11	98.18	1.28	99.46

ND referred to non detection (less than detection limit of equipment)

Table B-3 Removal of Cr at different initial concentration and solution pH by bagasse (Bagasse dose 20 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature)

Initial properties of solution		Final properties of solution					% Removal of Cr (VI)	% Removal of Total Cr
		No material		Add material				
Cr(VI) (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
5.052	1.02	5.052 ± 0.002	1.02	ND	3.998 ± 0.015	1.05	100.00	20.87
5.052	2.02	5.052 ± 0.003	2.02	ND	4.053 ± 0.048	2.05	100.00	19.77
5.052	3.01	5.052 ± 0.001	3.01	ND	4.161 ± 0.079	3.09	100.00	17.63
5.052	4.00	5.052 ± 0.003	4.00	ND	4.194 ± 0.088	4.08	100.00	16.99
5.052	5.05	5.052 ± 0.004	5.05	ND	4.270 ± 0.094	5.02	100.00	15.47
5.052	6.04	5.052 ± 0.003	6.04	ND	4.383 ± 0.039	6.09	100.00	13.24
10.113	1.01	10.113 ± 0.002	1.01	ND	8.138 ± 0.015	1.09	100.00	19.53
10.113	2.02	10.113 ± 0.004	2.02	ND	8.360 ± 0.102	2.07	100.00	17.33
10.113	3.02	10.113 ± 0.006	3.02	ND	8.562 ± 0.019	3.08	100.00	15.34
10.113	4.03	10.113 ± 0.004	4.03	ND	8.594 ± 0.106	4.09	100.00	15.02
10.113	5.00	10.113 ± 0.005	5.00	ND	8.685 ± 0.048	5.15	100.00	14.12
10.113	6.01	10.113 ± 0.005	6.01	ND	8.792 ± 0.097	6.09	100.00	13.06
20.306	1.00	20.306 ± 0.007	1.00	ND	16.440 ± 0.103	1.09	100.00	19.04
20.306	2.02	20.306 ± 0.006	2.02	ND	16.649 ± 0.201	2.08	100.00	18.01
20.306	3.01	20.306 ± 0.009	3.01	ND	17.311 ± 0.106	3.11	100.00	14.75
20.306	4.00	20.306 ± 0.005	4.00	ND	17.766 ± 0.103	4.12	100.00	12.51
20.306	5.04	20.306 ± 0.006	5.04	ND	17.802 ± 0.097	5.15	100.00	12.33
20.306	6.03	20.306 ± 0.007	6.03	ND	18.099 ± 0.066	6.16	100.00	10.87

Table B-3 (cont)

Initial properties of solution		Final properties of solution					% Removal of Cr (VI)	% Removal of Total Cr
		No material		Add material				
Cr(VI) (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
30.243	1.02	30.243 ± 0.008	1.02	ND	24.566 ± 0.102	1.11	100.00	18.77
30.243	2.02	30.243 ± 0.012	2.01	ND	24.996 ± 0.115	2.11	100.00	17.35
30.243	3.01	30.243 ± 0.009	3.03	ND	25.722 ± 0.116	3.09	100.00	14.95
30.243	4.00	30.243 ± 0.015	4.05	ND	26.810 ± 0.201	4.08	100.00	11.35
30.243	5.05	30.243 ± 0.048	5.06	ND	27.140 ± 0.118	5.09	100.00	10.26
30.243	6.04	30.243 ± 0.008	6.04	ND	27.367 ± 0.145	6.07	100.00	9.51
40.204	1.01	40.204 ± 0.048	1.02	ND	32.545 ± 0.124	1.09	100.00	19.05
40.204	2.02	40.204 ± 0.045	2.02	ND	33.550 ± 0.135	2.12	100.00	16.55
40.204	3.02	40.204 ± 0.057	3.08	ND	34.161 ± 0.113	3.11	100.00	15.03
40.204	4.03	40.204 ± 0.059	4.09	ND	36.035 ± 0.114	4.12	100.00	10.37
40.204	5.00	40.204 ± 0.058	5.01	2.436 ± 0.015	35.958 ± 0.147	5.09	93.94	10.56
40.204	6.01	40.204 ± 0.069	6.02	3.976 ± 0.069	36.883 ± 0.156	6.08	90.11	8.26
80.252	1.00	80.252 ± 0.043	1.01	ND	66.023 ± 0.245	1.03	100.00	17.73
80.252	2.02	80.252 ± 0.123	2.03	ND	68.760 ± 0.136	2.01	100.00	14.32
80.252	3.01	80.252 ± 0.096	3.04	5.104 ± 0.102	68.993 ± 0.147	3.05	93.64	14.03
80.252	4.00	80.252 ± 0.064	4.05	7.174 ± 0.039	72.580 ± 0.153	4.07	91.06	9.56
80.252	5.04	80.252 ± 0.175	5.00	10.954 ± 0.106	73.744 ± 0.149	5.12	86.35	8.11
80.252	6.03	80.252 ± 0.286	6.04	15.857 ± 0.119	74.426 ± 0.203	6.09	80.24	7.26

ND referred to non detection (less than detection limit of equipment)

Table B-4 Removal of Cr at difference initial concentration and solution pH by bagasse fly ash (Bagasse fly ash dose 20 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature)

Initial properties of solution		Final properties of solution					% Removal of Cr (VI)	% Removal of Total Cr
		No material		Add material				
Cr(VI) (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
5.052	1.02	5.052 ± 0.002	1.02	0.371 ± 0.012	1.033 ± 0.066	1.05	92.67	79.55
5.052	2.02	5.052 ± 0.003	2.02	0.954 ± 0.023	1.477 ± 0.087	2.05	81.12	70.77
5.052	3.01	5.052 ± 0.001	3.01	2.918 ± 0.036	3.306 ± 0.039	3.09	42.23	34.57
5.052	4.00	5.052 ± 0.003	4.00	3.530 ± 0.039	4.614 ± 0.055	4.08	30.12	8.66
5.052	5.05	5.052 ± 0.004	5.05	3.992 ± 0.044	4.948 ± 0.103	5.02	20.98	2.05
5.052	6.04	5.052 ± 0.003	6.04	4.439 ± 0.085	4.990 ± 0.095	6.09	12.14	1.23
10.113	1.01	10.113 ± 0.002	1.01	0.938 ± 0.057	2.861 ± 0.045	1.09	90.72	71.71
10.113	2.02	10.113 ± 0.004	2.02	2.505 ± 0.069	3.841 ± 0.066	2.07	75.23	62.02
10.113	3.02	10.113 ± 0.006	3.02	6.224 ± 0.067	6.962 ± 0.044	3.08	38.46	31.16
10.113	4.03	10.113 ± 0.004	4.03	7.656 ± 0.045	9.733 ± 0.099	4.09	24.29	3.76
10.113	5.00	10.113 ± 0.005	5.00	8.599 ± 0.036	10.003 ± 0.121	5.15	14.97	1.09
10.113	6.01	10.113 ± 0.005	6.01	9.237 ± 0.014	10.058 ± 0.066	6.09	8.66	0.54
20.306	1.00	20.306 ± 0.007	1.00	2.307 ± 0.061	8.827 ± 0.087	1.09	88.64	56.53
20.306	2.02	20.306 ± 0.006	2.02	5.439 ± 0.040	10.313 ± 0.069	2.08	73.22	49.21
20.306	3.01	20.306 ± 0.009	3.01	13.548 ± 0.031	14.005 ± 0.088	3.11	33.28	31.03
20.306	4.00	20.306 ± 0.005	4.00	16.212 ± 0.097	19.035 ± 0.034	4.12	20.16	6.26
20.306	5.04	20.306 ± 0.006	5.04	17.731 ± 0.907	20.036 ± 0.012	5.15	12.68	1.33
20.306	6.03	20.306 ± 0.007	6.03	18.818 ± 0.048	20.227 ± 0.067	6.16	7.33	0.39

Table B-4 (cont)

Initial properties of solution		Final properties of solution					% Removal of Cr (VI)	% Removal of Total Cr
		No material		Add material				
Cr(VI) (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
30.243	1.02	30.243 ± 0.008	1.05	3.941 ± 0.036	18.763 ± 0.057	1.06	86.97	37.96
30.243	2.02	30.243 ± 0.012	2.06	9.393 ± 0.046	20.411 ± 0.068	2.08	68.94	32.51
30.243	3.01	30.243 ± 0.009	3.04	22.948 ± 0.059	24.854 ± 0.069	3.04	24.12	17.82
30.243	4.00	30.243 ± 0.015	4.03	23.541 ± 0.103	27.554 ± 0.003	4.06	22.16	8.89
30.243	5.05	30.243 ± 0.048	5.07	26.623 ± 0.114	29.483 ± 0.101	5.07	11.97	2.513
30.243	6.04	30.243 ± 0.008	6.06	28.132 ± 0.106	30.157 ± 0.097	6.03	6.98	0.284
40.204	1.01	40.204 ± 0.048	1.05	5.854 ± 0.043	28.613 ± 0.082	1.02	85.44	28.83
40.204	2.02	40.204 ± 0.045	2.08	15.965 ± 0.063	29.755 ± 0.069	2.10	60.29	25.99
40.204	3.02	40.204 ± 0.057	3.09	27.077 ± 0.012	33.253 ± 0.104	3.10	32.65	17.29
40.204	4.03	40.204 ± 0.059	4.01	30.398 ± 0.037	37.263 ± 0.067	4.08	24.39	7.313
40.204	5.00	40.204 ± 0.058	5.06	34.001 ± 0.055	39.995 ± 0.112	5.08	15.43	0.52
40.204	6.01	40.204 ± 0.069	6.07	38.009 ± 0.085	40.128 ± 0.097	6.07	5.46	0.19
80.252	1.00	80.252 ± 0.043	1.03	35.833 ± 0.028	67.155 ± 0.066	1.04	55.35	16.32
80.252	2.02	80.252 ± 0.123	2.09	54.451 ± 0.105	69.370 ± 0.103	2.03	32.15	13.56
80.252	3.01	80.252 ± 0.096	3.06	66.729 ± 0.106	72.235 ± 0.099	3.06	16.85	9.99
80.252	4.00	80.252 ± 0.064	4.07	73.463 ± 0.058	74.554 ± 0.043	4.08	8.46	7.10
80.252	5.04	80.252 ± 0.175	5.03	79.290 ± 0.036	79.819 ± 0.057	5.06	1.198	0.54
80.252	6.03	80.252 ± 0.286	6.07	79.803 ± 0.082	80.075 ± 0.066	6.04	0.56	0.22

Appendix C

Effect of Material Dosage on Removal Efficiency

Table C-1 Removal of Pb at difference bagasse dose (volume of sample 50 mL, shaking speed 125 rpm, room temperature, contact time 60 min)

Adsorbent dose (g/L)	Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
			No adsorbent		Add adsorbent				
	Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
0.202	79.220	6.27	78.369 ± 0.002	6.27	60.793 ± 0.004	6.27	23.25	1.07	24.33
0.304	79.220	6.27	78.369 ±0.001	6.27	53.426 ± 0.014	6.27	32.55	1.07	33.63
0.406	79.220	6.27	78.369 ±0.001	6.27	51.873 ± 0.024	6.27	34.51	1.07	35.59
0.507	79.220	6.27	78.369 ±0.002	6.27	49.996 ±0.102	6.27	36.88	1.07	37.96
1.012	79.220	6.27	78.369 ±0.001	6.27	45.456 ±0.121	6.27	42.62	1.07	43.69
5.021	79.220	6.27	78.369 ±0.001	6.27	39.261 ± 0.114	6.04	50.44	1.07	51.51
10.007	79.220	6.27	78.369 ±0.003	6.27	33.336 ±0.104	6.14	57.92	1.07	58.99
15.006	79.220	6.27	78.369 ±0.001	6.27	30.294 ±0.046	6.04	61.76	1.07	62.83
20.014	79.220	6.27	78.369 ±0.002	6.27	29.517 ±0.150	5.89	62.74	1.07	63.81

Table C-2 Removal of Pb at difference bagasse fly ash dose (volume of sample 50 mL, shaking speed 125 rpm, room temperature, contact time 60 min)

Adsorbent dose (g/L)	Initial properties of solution		Final properties of solution				% Adsorption	% Precipitation	% Removal
			No adsorbent		Add adsorbent				
	Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH			
0.109	78.887	6.05	78.568 ± 0.003	6.05	53.635 ± 0.045	6.05	32.01	0.40	32.41
0.208	78.887	6.05	78.568 ± 0.005	6.05	32.714 ± 0.065	6.05	58.53	0.40	58.93
0.310	78.887	6.05	78.568 ± 0.002	6.05	23.469 ± 0.055	6.06	70.25	0.40	70.65
0.406	78.887	6.05	78.568 ± 0.002	6.05	19.375 ± 0.062	6.08	75.44	0.40	75.84
0.501	78.887	6.05	78.568 ± 0.003	6.05	16.937 ± 0.045	6.07	78.52	0.40	78.93
0.998	78.887	6.05	78.568 ± 0.004	6.05	10.484 ± 0.036	6.09	86.71	0.40	87.11
5.031	78.887	6.05	78.568 ± 0.003	6.05	1.949± 0.076	6.09	97.53	0.40	97.93
10.005	78.887	6.05	78.568 ± 0.006	6.05	0.544 ± 0.069	6.11	99.30	0.40	99.71
14.995	78.887	6.05	78.568 ± 0.003	6.05	0.410 ± 0.045	6.15	99.48	0.40	99.88
20.004	78.887	6.05	78.568 ± 0.002	6.05	0.339 ± 0.102	6.18	99.57	0.40	99.97

Table C-3 Removal of Cr at difference bagasse dose (volume of sample 50 mL, shaking speed 125 rpm, room temperature, contact time 60 min)

Adsorbent dose (g/L)	Initial properties of solution		Final properties of solution					% Removal of Cr(VI)	% Removal of Total Cr
			No material		Add material				
	Cr(VI) Conc. (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
1.015	80.046	1.09	80.046 ± 0.002	1.09	62.411 ± 0.066	77.589 ± 0.099	1.05	22.03	3.07
5.023	80.046	1.09	80.046 ± 0.001	1.09	45.827 ± 0.067	73.410 ± 0.064	1.06	42.75	8.29
10.113	80.046	1.09	80.046 ± 0.003	1.09	12.127 ± 0.045	69.624 ± 0.075	1.08	84.85	13.02
15.045	80.046	1.09	80.046 ± 0.001	1.09	2.577 ± 0.069	67.751 ± 0.085	1.09	96.78	15.36
20.088	80.046	1.09	80.046 ± 0.001	1.09	ND	64.741 ± 0.088	1.07	100.00	19.12
25.046	80.046	1.09	80.046 ± 0.002	1.09	ND	64.581 ± 0.094	1.09	100.00	19.32
30.058	80.046	1.09	80.046 ± 0.002	1.09	ND	64.005 ± 0.067	1.10	100.00	20.04
39.955	80.046	1.09	80.046 ± 0.001	1.09	ND	64.653 ± 0.091	1.09	100.00	19.23

ND referred to non detection (less than detection limit of equipment)

Table C-4 Removal of Cr at difference bagasse fly ash dose (volume of sample 50 mL, shaking speed 125 rpm, room temperature, contact time 60 min)

Adsorbent dose (g/L)	Initial properties of solution		Final properties of solution					% Removal of Cr(VI)	% Removal of Total Cr
			No material		Add material				
	Cr(VI) Conc. (mg/L)	pH	Cr(VI) Conc.(mg/L) ± SD	pH	Cr(VI) Conc.(mg/L) ± SD	Total Cr Conc.(mg/L) ± SD	pH		
1.021	80.046	1.09	80.046 ± 0.002	1.09	69.144 ± 0.036	75.211 ± 0.067	1.04	13.62	6.04
5.041	80.046	1.09	80.046 ± 0.001	1.09	57.761 ± 0.011	64.573 ± 0.099	1.06	27.84	19.33
10.014	80.046	1.09	80.046 ± 0.003	1.09	49.749 ± 0.015	55.272 ± 0.103	1.06	37.85	30.95
15.023	80.046	1.09	80.046 ± 0.001	1.09	34.235 ± 0.106	48.149 ± 0.014	1.09	57.23	39.85
19.994	80.046	1.09	80.046 ± 0.001	1.09	26.879 ± 0.054	42.977 ± 0.106	1.04	66.42	46.31
25.041	80.046	1.09	80.046 ± 0.002	1.09	16.498 ± 0.096	40.661 ± 0.058	1.02	79.39	49.19
30.033	80.046	1.09	80.046 ± 0.002	1.09	14.456 ± 0.068	38.454 ± 0.067	1.09	81.94	51.96
40.054	80.046	1.09	80.046 ± 0.001	1.09	12.735 ± 0.066	35.076 ± 0.094	1.07	84.09	56.18

Appendix D

Isotherm Equation Analysis

Table D-1 Adsorption isotherm equation data for removal Pb by bagasse at difference dosage of bagasse.

Dose (g/L)	Co (mg/L)	Ce (mg/L)	x (mg/L)	q (mg/g)	1/Ce	1/q	log Ce	log q
0.20	79.220	60.797	18.423	92.113	0.016	0.011	1.784	1.964
0.30	79.220	53.431	25.789	85.964	0.019	0.012	1.728	1.934
0.40	79.220	51.880	27.340	68.350	0.019	0.015	1.715	1.835
0.50	79.220	50.000	29.220	58.439	0.020	0.017	1.699	1.767
1.00	79.220	45.455	33.765	33.765	0.022	0.030	1.658	1.528
5.00	79.220	39.264	39.956	7.991	0.025	0.125	1.594	0.903
10.00	79.220	33.333	45.887	4.589	0.030	0.218	1.523	0.662
15.00	79.220	30.294	48.925	3.262	0.033	0.307	1.481	0.513
20.00	79.220	29.522	49.698	2.485	0.034	0.402	1.470	0.395

Table D-2 Adsorption isotherm equation data for removal Pb by bagasse fly ash at difference dosage of bagasse fly ash.

Dose (g/L)	Co (mg/L)	Ce (mg/L)	x (mg/L)	q (mg/g)	1/Ce	1/q	log Ce	log q
0.10	78.887	53.637	25.250	252.500	0.019	0.004	1.729	2.402
0.20	78.887	32.716	46.171	230.855	0.031	0.004	1.515	2.363
0.30	78.887	23.471	55.416	184.720	0.043	0.005	1.371	2.267
0.40	78.887	19.377	59.510	148.775	0.052	0.007	1.287	2.173
0.50	78.887	16.943	61.944	123.888	0.059	0.008	1.229	2.093
1.00	78.887	10.485	68.402	68.402	0.095	0.015	1.021	1.835
5.00	78.887	1.952	76.935	15.387	0.512	0.065	0.290	1.187
10.00	78.887	0.550	78.337	7.834	1.818	0.128	-0.260	0.894
15.00	78.887	0.413	78.474	5.232	2.421	0.191	-0.384	0.719
20.00	78.887	0.346	78.541	3.927	2.890	0.255	-0.461	0.594

Appendix E

Kinetic Analysis

Table E-1 Kinetic analysis data for removal Cr(VI) by bagasse

Contact time (min)	Cr(VI)			
	Co (mg/L)	Ce (mg/L)	ln Ce	Co-Ce (mg/L)
0	10.440	10.440	2.346	0.000
3	10.440	10.440	2.346	0.000
6	10.440	9.260	2.226	1.180
9	10.440	8.061	2.087	2.379
12	10.440	6.951	1.939	3.489
15	10.440	3.570	1.273	6.870
30	10.440	ND	-	-

ND referred to non detection (less than detection limit of equipment)

Table E-2 Kinetic analysis data for removal Cr by bagasse fly ash

Contact time (min)	Cr(VI)			
	Co (mg/L)	Ce (mg/L)	ln Ce	Co-Ce (mg/L)
0	9.209	9.209	2.220	0
3	9.209	9.209	2.220	0
6	9.209	6.270	1.836	2.939
9	9.209	5.5825	1.719	3.626
12	9.209	5.364	1.680	3.845
15	9.209	4.647	1.536	4.562
30	9.209	2.874	1.056	6.335

Appendix F

Adsorption Capacity

Table F Sorption uptake of bagasse (B) and bagasse fly ash (BFA) on lead (Pb) and chromium (Cr)

Initial conc. (mg/L)	Initial pH	Adsorption uptake, q (mg/g)			
		B-Pb	BFA-Pb	B-Cr	BFA-Cr
5	1	0.003	0.502	0.053	0.201
5	2	0.013	0.517	0.050	0.179
5	3	0.155	ND	0.045	0.087
5	4	0.318	ND	0.043	0.022
5	5	0.388	ND	0.039	0.005
5	6	0.468	ND	0.033	0.003
10	1	0.018	1.018	0.099	0.363
10	2	0.029	1.049	0.088	0.316
10	3	0.339	1.117	0.078	0.158
10	4	0.531	1.171	0.076	0.019
10	5	0.813	ND	0.071	0.005
10	6	0.873	ND	0.066	0.003
20	1	0.035	1.488	0.193	0.574
20	2	0.055	1.524	0.183	0.499
20	3	0.240	1.859	0.150	0.315
20	4	0.738	1.932	0.127	0.063
20	5	1.311	1.959	0.125	0.014
20	6	1.594	1.972	0.110	0.004
30	1	0.055	1.956	0.284	0.574
30	2	0.086	2.092	0.262	0.491
30	3	0.294	2.729	0.226	0.270
30	4	0.903	2.878	0.172	0.135
30	5	1.657	2.924	0.155	0.038
30	6	2.162	2.947	0.144	0.004
40	1	0.106	2.343	0.383	0.580
40	2	0.111	2.588	0.333	0.523
40	3	0.134	3.870	0.302	0.347
40	4	1.038	4.114	0.208	0.147
40	5	1.972	4.174	0.212	0.010
40	6	2.724	4.207	0.166	0.004
80	1	0.177	1.824	0.711	0.655
80	2	0.270	2.249	0.575	0.544
80	3	0.844	6.708	0.563	0.401
80	4	1.457	7.182	0.384	0.285
80	5	2.712	7.671	0.325	0.022
80	6	4.055	7.915	0.291	0.009

Appendix G

Effect of percent replacement and w/c ratio on compressive strength of specimen in S/S study

Table G-1 Compressive strength of B-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.40	0	25.70	56.5	224.30	26.11	58.0	226.62	26.11	62.2	242.80	231.24
	5	26.11	18.3	71.49	26.16	18.5	72.22	25.86	19.6	77.38	73.70
	10	25.86	1.0	3.96	25.96	1.0	3.92	25.50	1.0	4.12	4.00
0.50	0	25.91	57.9	227.95	26.01	56.4	221.04	26.21	62.2	241.76	230.25
	5	25.75	17.1	67.54	25.86	17.0	66.84	26.00	19.0	74.50	69.63
	10	26.42	1.2	4.55	25.40	1.1	4.55	25.70	1.3	5.12	4.74
0.60	0	26.57	47.1	180.89	26.94	47.8	180.89	26.06	52.0	203.50	188.43
	5	26.47	4.8	18.56	26.47	4.9	18.95	26.27	5.3	20.49	19.33
	10	25.55	0.4	1.61	25.25	0.4	1.63	26.11	0.5	1.79	1.68
0.70	0	26.11	35.3	137.97	25.81	35.7	140.87	25.55	39.3	156.85	145.23
	5	26.11	2.3	9.09	26.00	2.3	9.09	26.16	2.7	10.53	9.57
	10	25.91	0.2	0.79	26.21	0.2	0.77	26.01	0.2	0.88	0.81

Table G-2 Compressive strength of B-Pb-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.40	0	26.01	59.0	231.37	26.01	59.6	233.76	25.91	63.7	250.46	238.53
	5	25.86	19.1	75.15	25.70	19.1	75.92	25.60	20.4	81.34	77.47
	10	25.50	1.0	4.02	25.60	1.0	3.98	25.91	1.1	4.18	4.06
0.50	0	26.21	57.5	223.46	25.96	55.2	216.69	26.21	60.9	237.01	225.72
	5	26.00	16.5	64.70	25.50	16.0	64.03	26.36	18.5	71.37	66.70
	10	25.85	1.0	3.96	25.40	1.0	3.96	25.80	1.1	4.45	4.12
0.60	0	26.11	42.1	164.40	26.32	42.4	164.40	26.06	47.3	184.95	171.25
	5	26.27	6.1	23.48	26.57	6.2	23.97	26.42	6.7	25.93	24.46
	10	26.11	0.5	1.99	25.40	0.5	2.01	26.11	0.6	2.21	2.07
0.70	0	26.32	34.5	133.64	26.21	35.1	136.45	25.60	38.2	151.92	140.67
	5	26.16	3.0	11.62	25.75	2.9	11.62	26.16	3.5	13.45	12.23
	10	26.16	0.3	1.03	26.21	0.3	1.01	26.01	0.3	1.14	1.06

Table G-3 Compressive strength of B-Cr-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.40	0	26.11	54.9	214.20	25.96	55.1	216.41	25.76	58.6	231.85	220.82
	5	25.65	17.2	68.46	25.70	17.4	69.16	26.01	18.9	74.12	70.58
	10	25.60	1.0	4.07	25.60	1.0	4.03	25.75	1.1	4.23	4.11
0.50	0	25.96	58.5	229.79	25.96	56.7	222.82	25.91	61.9	243.72	232.11
	5	26.57	17.3	66.33	25.70	16.5	65.64	25.60	18.4	73.17	68.38
	10	25.80	1.2	4.70	25.45	1.2	4.70	26.10	1.4	5.30	4.90
0.60	0	26.63	49.1	188.08	26.32	48.6	188.08	25.81	53.6	211.57	195.91
	5	26.52	6.2	24.02	26.63	6.4	24.52	26.16	6.8	26.52	25.02
	10	25.70	0.5	1.82	25.40	0.5	1.84	25.96	0.5	2.04	1.90
0.70	0	26.57	36.5	140.16	26.21	36.8	143.12	25.45	39.8	159.34	147.54
	5	26.00	2.6	10.30	25.55	2.6	10.30	26.11	3.1	11.92	10.84
	10	26.42	0.2	0.90	26.21	0.2	0.88	25.50	0.3	1.01	0.93

Table G-4 Compressive strength of BFA-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.40	0	25.70	64.4	255.35	26.11	66.1	257.99	26.11	70.8	276.41	263.25
	10	26.11	37.1	144.84	26.16	37.6	146.33	25.86	39.8	156.78	149.32
	20	25.86	26.7	105.08	25.96	26.5	104.02	25.50	27.3	109.33	106.14
	30	26.06	22.3	87.10	25.65	21.7	86.22	25.55	22.7	90.62	87.98
0.50	0	25.91	71.5	281.40	26.01	69.6	272.87	26.21	76.7	298.45	284.24
	10	25.75	40.3	159.43	25.86	40.0	157.79	26.00	44.9	175.87	164.36
	20	26.42	29.2	112.71	25.40	28.1	112.71	25.70	32.0	126.80	117.40
	30	26.57	26.3	100.84	26.21	25.9	100.84	26.06	29.0	113.45	105.05
0.60	0	26.57	58.7	225.38	26.94	59.6	225.38	26.06	64.8	253.55	234.77
	10	26.47	30.8	118.68	26.47	31.5	121.16	26.27	33.8	131.05	123.63
	20	25.55	22.3	88.91	25.25	22.3	89.84	26.11	25.4	99.10	92.62
	30	25.60	19.2	76.41	25.30	19.4	78.02	26.00	22.2	86.87	80.43
0.70	0	26.11	45.0	175.65	25.81	45.4	179.34	25.55	50.0	199.68	184.89
	10	26.11	22.7	88.46	26.00	22.6	88.46	26.16	26.3	102.42	93.11
	20	25.91	16.3	63.97	26.21	16.1	62.65	26.01	18.2	71.23	65.95
	30	26.37	14.8	57.34	26.47	14.6	56.15	26.01	16.3	63.84	59.11

Table G-5 Compressive strength of BFA-Pb-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.40	0	27.04	72.0	271.43	27.04	69.0	260.12	26.52	66.0	253.69	261.75
	10	26.01	38.0	148.93	26.01	41.0	160.68	26.00	38.0	148.98	152.87
	20	26.52	27.5	105.70	26.52	27.5	105.70	26.52	26.5	101.86	104.42
	30	27.04	24.0	90.48	27.04	28.0	105.56	26.52	26.5	101.86	99.30
0.50	0	25.50	67.0	267.83	26.01	70.0	274.34	25.5	65.0	259.84	267.34
	10	26.01	43.0	168.52	27.04	43.0	162.10	26.52	41.0	157.59	162.74
	20	27.04	30.0	113.10	27.04	29.5	111.21	26.01	29.5	115.61	113.31
	30	27.04	31.5	118.75	27.04	30.0	113.10	27.04	33.0	124.41	118.75
0.60	0	25.00	57.0	232.42	25.5	60.0	239.85	27.04	55.0	207.34	226.54
	10	27.04	30.0	113.10	27.04	33.0	124.41	26.01	34.0	133.25	123.58
	20	27.04	24.0	90.48	27.04	23.5	88.59	26.01	24.0	94.06	91.04
	30	26.01	18.5	72.50	27.04	18.5	69.74	26.52	20.5	78.80	73.68
0.70	0	26.01	50.0	195.96	26.01	46.0	180.28	26.01	46.0	180.28	185.51
	10	26.52	22.0	84.56	26.52	26.0	99.94	26.01	25.0	97.98	94.16
	20	28.09	17.5	63.51	27.04	18.0	67.86	26.01	18.0	70.54	67.30
	30	27.04	17.0	64.09	26.01	14.0	54.87	26.01	16.0	62.71	60.55

Table G-6 Compressive strength of BFA-Cr-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.40	0	25.96	65.2	256.08	25.76	65.4	258.72	26.11	71.0	277.20	264.00
	10	25.65	35.0	139.10	25.91	35.7	140.54	26.31	38.9	150.58	143.40
	20	25.60	26.5	105.46	25.75	26.4	104.39	25.86	27.8	109.72	106.52
	30	25.96	23.6	92.70	25.45	22.9	91.77	25.30	23.9	96.45	93.64
0.50	0	25.96	83.2	326.70	26.11	81.1	316.80	26.27	89.3	346.50	330.00
	10	25.70	48.1	190.91	25.60	47.4	188.94	25.30	52.3	210.59	196.81
	20	25.45	32.6	130.62	26.10	33.4	130.62	25.45	36.7	146.94	136.06
	30	26.16	32.6	127.16	26.31	32.8	127.16	25.91	36.4	143.06	132.46
0.60	0	27.04	63.4	239.04	25.81	60.5	239.04	26.16	69.0	268.92	249.00
	10	26.63	33.2	126.95	26.21	33.3	129.60	26.21	36.0	140.18	132.24
	20	25.40	23.0	92.37	25.96	23.8	93.33	25.65	25.9	102.95	96.21
	30	25.60	20.0	79.67	26.31	21.0	81.35	26.00	23.1	90.57	83.86
0.70	0	26.01	44.6	174.80	25.45	44.6	178.48	25.55	49.8	198.72	184.00
	10	25.55	22.0	87.87	25.70	22.2	87.87	26.16	26.1	101.75	92.50
	20	26.21	15.7	61.15	25.50	15.0	59.89	25.80	17.2	68.08	63.04
	30	26.37	14.8	57.38	26.11	14.4	56.20	25.96	16.3	63.89	59.16

Appendix H

Effect of Curing Time on Compressive Strength of Specimens in S/S Study

Table H-1 Compressive strength of B-cement mortar with difference curing time and percent replacement at w/c ratio of 0.50

Percent replacement	Curing time (day)	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0	3	25.70	44.1	174.85	26.11	45.2	176.65	26.11	48.5	189.27	180.26
	7	26.06	60.0	234.85	26.16	60.9	237.27	25.65	64.0	254.22	242.11
	14	25.91	70.4	276.84	25.86	69.5	274.05	25.70	72.6	288.03	279.64
	28	25.91	83.7	329.29	25.96	81.3	319.32	26.21	89.8	349.25	332.62
5	3	26.42	0.7	2.66	25.40	0.7	2.66	26.01	0.8	3.00	2.78
	7	26.27	18.8	73.12	26.31	18.9	73.12	26.06	21.0	82.26	76.17
	14	26.11	26.4	103.14	26.47	27.3	105.29	25.86	28.9	113.88	107.44
	28	25.55	35.5	141.65	25.50	35.8	143.12	26.11	40.4	157.88	147.55

Table H-2 Compressive strength of B-Pb-cement mortar with difference curing time and percent replacement at w/c ratio of 0.50

Percent replacement	Curing time (day)	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0	3	25.60	42.7	169.99	25.35	42.7	171.75	25.65	46.3	184.01	175.25
	7	25.96	59.4	233.20	25.65	59.3	235.60	25.50	63.1	252.43	240.41
	14	26.47	69.4	267.10	25.65	66.5	264.40	25.91	70.6	277.89	269.80
	28	26.06	81.4	318.32	25.65	77.7	308.68	25.81	85.5	337.62	321.54
5	3	25.86	0.4	1.50	25.50	0.4	1.50	25.91	0.4	1.68	1.56
	7	25.20	18.7	75.68	26.05	19.3	75.68	25.60	21.4	85.14	78.83
	14	26.11	25.8	100.91	25.60	25.9	103.01	25.91	28.3	111.42	105.11
	28	25.75	35.2	139.35	26.21	36.2	140.81	25.55	38.9	155.32	145.16

Table H-3 Compressive strength of B-Cr-cement mortar with difference curing time and percent replacement at w/c ratio of 0.50

Percent replacement	Curing time (day)	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0	3	25.81	44.8	176.84	25.81	45.2	178.66	25.96	48.8	191.43	182.31
	7	25.91	59.7	234.85	25.80	60.1	237.27	25.65	64.0	254.21	242.11
	14	25.60	71.9	286.29	25.86	71.9	283.40	25.76	75.3	297.86	289.18
	28	25.96	86.2	338.58	25.76	83.0	328.32	26.21	92.3	359.10	342.00
5	3	26.42	0.7	2.66	25.40	0.7	2.66	25.96	0.8	2.99	2.77
	7	26.00	18.2	71.47	26.31	18.4	71.47	26.06	20.6	80.40	74.45
	14	26.26	28.2	109.52	26.83	29.4	111.80	26.32	31.2	120.93	114.08
	28	25.75	37.6	148.93	25.75	38.0	150.48	25.96	42.3	165.99	155.13

Table H-4 Compressive strength of BFA-cement mortar with difference curing time and percent replacement at w/c ratio of 0.50

Percent replacement	Curing time	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm²)	Compressive strength		Area (cm²)	Compressive strength		Area (cm²)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0	3	25.70	41.6	164.90	26.11	42.7	166.60	26.11	45.7	178.50	170.00
	7	26.11	57.6	225.04	26.16	58.3	227.36	25.86	61.8	243.60	232.00
	14	25.86	67.3	265.32	25.96	66.9	262.64	25.50	69.1	276.04	268.00
	28	25.91	75.5	297.00	26.01	73.5	288.00	26.21	81.0	315.00	300.00
	60	25.75	80.6	319.13	25.86	80.1	315.84	26.00	89.8	352.03	329.00
10	3	26.42	31.3	120.93	25.40	30.1	120.93	25.70	34.3	136.05	125.97
	7	26.57	33.8	129.85	26.94	34.3	129.85	26.06	37.3	146.08	135.26
	14	26.47	39.6	152.57	26.47	40.4	155.75	26.27	43.4	168.46	158.92
	28	25.55	42.1	167.90	25.25	42.0	169.65	26.11	47.9	187.14	174.90
	60	26.11	46.0	179.40	25.81	46.4	183.18	25.55	51.1	203.95	188.85

Table H-5 Compressive strength of BFA-Pb-cement mortar with difference curing time and percent replacement at w/c ratio of 0.50

Percent replacement	Curing time	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0	3	26.01	46.0	180.28	26.01	46.0	180.28	25.50	44.0	175.89	178.82
	7	25.50	67.0	267.83	26.01	70.0	274.34	25.50	65.0	259.84	267.34
	14	26.01	71.0	278.26	26.01	75.0	293.94	26.01	69.0	270.42	280.87
	28	27.04	77.0	290.28	26.01	76.0	297.85	26.01	78.0	305.69	297.94
	60	25.50	85.0	339.79	26.01	85.0	333.13	26.00	87.0	341.10	338.00
10	3	27.04	34.0	128.17	27.04	36.0	135.71	26.01	36.0	141.09	134.99
	7	26.01	43.0	168.52	27.04	43.0	162.10	26.52	41.0	157.59	162.74
	14	27.04	48.0	180.95	26.52	47.0	180.66	27.04	43.0	162.10	174.57
	28	26.01	50.0	195.96	25.50	52.0	207.87	26.01	50.0	195.96	199.93
	60	26.52	57.0	219.09	25.50	50.0	199.88	25.50	57.0	227.86	215.61

Table H-6 Compressive strength of BFA-Cr-cement mortar with difference curing time and percent replacement at w/c ratio of 0.50

Percent replacement	Curing time (day)	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0	3	25.55	36.7	146.47	25.60	37.2	147.98	25.60	39.8	158.55	151.00
	7	26.11	58.4	227.95	26.16	59.1	230.30	25.86	62.6	246.75	235.00
	14	26.01	72.0	282.15	26.21	71.8	279.30	25.81	74.3	293.55	285.00
	28	26.01	78.8	308.88	26.32	77.3	299.52	26.21	84.2	327.60	312.00
	60	25.70	83.1	329.80	25.86	82.8	326.40	25.50	91.0	363.80	340.00
10	3	25.90	24.7	97.15	26.26	25.0	97.15	25.70	27.6	109.30	101.20
	7	25.50	33.9	135.43	26.57	35.3	135.43	25.96	38.8	152.36	141.07
	14	26.47	41.5	160.00	26.01	41.7	163.33	26.27	45.5	176.67	166.67
	28	25.76	45.2	179.05	25.55	45.3	180.92	26.16	51.2	199.57	186.51
	60	26.11	45.7	178.39	25.81	46.1	182.15	26.05	51.8	202.80	187.78

Appendix I

Effect of Percent Replacement and w/c ratio on Compressive Strength of Specimens in Construction Material Study

Table I-1 Compressive strength of BFA-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.40	103.6	415.90	25.65	117.0	464.83	25.60	119.8	477.07	452.60
	10	26.06	109.5	428.14	26.10	115.9	452.60	26.06	102.2	399.60	426.78
	20	25.91	80.6	317.05	26.21	98.5	383.28	25.30	103.5	416.90	372.41
	30	25.91	77.2	303.87	25.60	80.4	320.18	26.62	85.7	328.36	317.47
0.5	0	25.60	99.3	395.52	26.01	103.0	403.67	25.91	101.6	399.58	399.59
	10	26.21	93.3	362.90	25.76	92.8	367.38	26.00	93.6	366.97	365.75
	20	25.91	73.1	287.46	25.91	82.9	326.20	26.06	99.5	389.39	334.35
	30	25.40	74.2	297.66	26.21	78.6	305.81	26.16	86.9	338.44	313.97
0.6	0	26.57	91.4	350.66	25.86	92.1	362.90	25.60	92.2	366.98	360.18
	10	26.01	79.1	309.89	26.11	77.3	301.73	25.05	75.1	305.81	305.81
	20	25.76	84.0	332.31	25.55	70.5	281.35	25.81	59.9	236.48	283.38
	30	25.76	67.0	265.04	25.30	66.8	269.11	26.16	68.5	267.06	267.07
0.7	0	25.86	78.6	309.89	25.76	81.4	322.12	25.76	80.4	318.03	316.68
	10	25.65	66.7	265.04	25.60	54.3	216.11	26.31	74.7	289.49	256.88
	20	25.91	60.1	236.49	25.25	59.6	240.57	25.96	61.3	240.57	239.21
	30	25.86	57.9	228.34	25.80	48.5	191.64	26.32	66.9	258.92	226.30

Table I-2 Compressive strength of BFA-Pb-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.70	104.9	415.90	26.11	119.1	464.83	26.11	122.2	477.06	452.60
	10	26.11	108.7	424.50	26.16	107.7	419.80	25.86	106.8	420.80	421.70
	20	25.86	96.0	378.30	25.96	96.0	377.10	25.50	95.8	383.10	379.50
	30	26.06	79.3	310.00	25.65	79.6	316.30	25.55	78.5	313.30	313.20
0.5	0	25.91	100.5	395.52	26.01	103.0	403.67	26.21	102.7	399.59	399.59
	10	25.75	88.6	350.60	25.86	91.7	361.40	26.00	92.2	361.40	357.80
	20	26.42	82.1	316.80	25.40	81.0	325.10	25.70	84.3	334.30	325.40
	30	26.57	80.8	309.90	26.21	79.3	308.30	26.06	80.9	316.30	311.50
0.6	0	26.57	91.4	350.66	26.94	95.9	362.90	26.06	93.8	366.97	360.18
	10	26.47	77.2	297.30	26.47	77.8	299.60	26.27	78.3	304.00	300.30
	20	25.55	70.5	281.20	25.25	68.5	276.40	26.11	75.6	295.30	284.30
	30	25.60	66.4	264.30	25.30	63.3	255.10	26.00	70.8	277.40	265.60
0.7	0	26.11	79.4	309.89	25.81	81.6	322.12	25.55	79.7	318.04	316.68
	10	26.11	64.7	252.60	26.00	65.1	255.40	26.16	63.9	248.90	252.30
	20	25.91	58.1	228.40	26.21	59.7	232.20	26.01	63.4	248.30	236.30
	30	26.37	56.5	218.40	26.47	60.0	231.00	26.01	58.9	230.70	226.70

Table I-3 Compressive strength of BFA-Cr-cement mortar with difference percent replacement and w/c ratio at 7-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.70	104.9	415.90	26.42	120.5	464.83	25.65	120.0	477.06	452.60
	10	26.06	107.8	421.70	26.16	109.5	426.80	26.06	108.7	425.00	424.50
	20	25.86	94.1	371.10	26.21	94.0	365.70	25.30	91.4	368.40	368.40
	30	26.26	83.8	325.30	25.55	79.8	318.40	26.00	84.8	332.50	325.40
0.5	0	25.60	99.3	395.52	26.01	103.0	403.67	26.37	103.4	399.59	399.59
	10	26.06	89.1	348.40	25.86	90.1	355.30	26.00	92.2	361.60	355.10
	20	25.91	84.2	331.20	25.81	86.0	339.50	26.21	88.1	342.70	337.80
	30	26.11	81.7	318.90	26.21	83.3	324.10	26.16	82.6	321.80	321.60
0.6	0	26.57	91.4	350.66	26.36	93.8	362.90	25.55	92.0	366.97	360.18
	10	26.11	79.7	311.30	26.11	79.7	311.30	25.05	75.8	308.60	310.40
	20	25.76	69.1	273.40	26.57	72.6	278.60	26.11	72.6	283.50	278.50
	30	25.60	64.1	255.40	25.20	64.6	261.20	26.16	71.3	277.80	264.80
0.7	0	25.86	78.6	309.89	25.76	81.4	322.12	25.35	79.1	318.04	316.68
	10	25.96	65.1	255.80	25.60	65.2	259.50	26.57	69.5	266.80	260.70
	20	25.91	61.4	241.40	25.86	60.0	236.50	26.11	63.6	248.40	242.10
	30	25.65	54.6	216.90	25.80	57.9	228.70	26.32	61.8	239.30	228.30

Table I-4 Compressive strength of BFA-cement mortar with difference percent replacement and w/c ratio at 5-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.81	85.8	338.90	25.81	87.2	344.33	25.81	112.7	445.17	376.13
	10	25.96	82.9	325.67	25.50	80.4	321.40	25.81	79.2	312.93	320.00
	20	25.91	75.4	296.80	25.81	75.8	299.20	25.80	76.6	302.50	299.50
	30	25.60	45.8	182.40	26.01	47.3	185.30	25.45	47.2	189.10	185.60
0.5	0	25.65	63.3	251.67	25.50	64.8	259.10	25.70	65.5	259.63	256.80
	10	25.15	61.2	248.10	26.11	62.7	244.67	25.20	60.4	244.43	245.73
	20	25.91	49.3	194.00	25.50	48.8	195.13	25.65	50.8	202.07	197.07
	30	26.57	46.2	177.30	25.80	46.2	182.67	25.30	46.4	186.83	182.27
0.6	0	26.31	59.5	230.40	26.31	60.7	235.20	25.30	59.6	240.00	235.20
	10	28.90	64.0	225.70	26.37	57.3	221.40	26.57	56.1	215.30	220.80
	20	25.70	51.8	205.50	25.80	53.2	210.33	26.06	53.2	208.17	208.00
	30	26.31	41.7	161.60	25.50	39.2	156.80	26.52	41.8	160.70	159.70
0.7	0	26.32	49.2	190.70	25.30	48.1	193.67	26.05	46.0	180.13	188.17
	10	26.42	40.6	156.50	25.05	40.4	164.50	25.50	41.0	163.80	161.60
	20	25.91	41.4	162.90	25.60	39.6	157.70	25.50	39.9	159.40	160.00
	30	25.86	31.9	125.90	25.95	30.9	121.40	25.86	34.1	134.30	127.20

Table I-5 Compressive strength of BFA-Pb-cement mortar with difference percent replacement and w/c ratio at 5-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.70	71.3	282.80	25.65	70.1	278.60	25.65	72.5	288.20	283.20
	10	26.01	83.9	328.90	25.81	83.9	331.20	26.11	84.6	330.20	330.10
	20	26.21	75.6	294.10	25.81	75.1	296.67	26.16	75.8	295.23	295.33
	30	25.00	45.8	186.80	26.47	48.1	185.33	25.91	45.0	177.17	183.10
0.5	0	25.95	61.6	241.90	25.25	62.0	250.10	25.40	60.3	242.20	244.73
	10	25.20	60.9	246.40	26.01	62.0	243.10	25.80	62.4	246.40	245.30
	20	26.52	50.9	195.70	25.86	50.5	199.20	26.06	51.2	200.10	198.33
	30	26.00	47.0	184.20	25.75	45.5	180.20	25.55	47.8	190.90	185.10
0.6	0	25.65	31.3	124.30	26.31	32.3	125.00	25.60	44.5	177.10	142.13
	10	28.00	62.3	226.90	26.37	57.3	221.40	26.31	55.6	215.60	221.30
	20	26.06	50.4	197.30	26.01	52.5	205.67	25.81	52.3	206.63	203.20
	30	26.16	42.7	166.30	25.50	42.4	169.40	25.81	41.6	164.40	166.70
0.7	0	25.60	19.4	77.13	25.45	18.1	72.33	26.42	19.4	74.93	74.80
	10	26.26	42.2	163.90	25.60	40.2	160.00	25.76	42.1	166.70	163.53
	20	25.76	38.2	151.20	25.60	38.4	152.90	25.60	42.5	169.30	157.80
	30	25.30	30.1	121.40	25.50	32.4	129.50	25.86	31.8	125.30	125.40

Table I-6 Compressive strength of BFA-Cr-cement mortar with difference percent replacement and w/c ratio at 5-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.81	71.6	282.80	25.76	70.4	278.60	25.91	73.3	288.20	283.20
	10	26.01	84.3	330.30	25.81	81.3	321.00	26.11	83.4	325.70	325.67
	20	26.11	76.2	297.50	26.21	76.0	295.70	26.06	75.9	296.80	296.67
	30	25.00	46.2	188.20	26.47	49.3	190.00	25.91	48.5	190.80	189.67
0.5	0	25.15	59.7	241.90	25.35	62.2	250.10	25.00	59.4	242.20	244.73
	10	25.20	61.0	246.80	26.01	61.5	241.20	25.80	64.9	256.30	248.10
	20	25.81	52.1	205.90	25.91	50.8	200.00	25.91	50.3	197.70	201.20
	30	26.00	48.0	188.20	25.75	45.9	181.60	25.55	45.5	181.60	183.80
0.6	0	25.76	31.4	124.30	25.30	31.0	125.00	25.75	44.7	177.10	142.13
	10	28.00	60.8	221.50	26.37	56.6	218.70	26.31	59.7	231.20	223.80
	20	25.50	52.7	210.50	25.60	52.7	210.00	25.45	54.1	216.70	212.40
	30	26.16	39.1	152.40	25.50	38.7	154.60	25.81	42.5	167.90	158.30
0.7	0	26.16	19.8	77.13	25.40	18.0	72.33	26.31	19.3	74.93	74.80
	10	26.26	44.4	172.40	25.60	41.3	164.60	25.76	39.2	155.30	164.10
	20	25.60	37.7	150.00	25.45	37.1	148.70	25.86	42.3	166.90	155.20
	30	25.30	30.9	124.60	25.50	32.0	127.80	25.86	35.6	140.30	130.90

Table I-7 Compressive strength of BFA-cement mortar with difference percent replacement and w/c ratio at 3-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.81	71.6	282.80	25.81	70.5	278.6C	25.81	73.0	288.20	283.20
	10	25.96	73.9	290.30	25.50	71.7	286.60	25.81	77.6	306.30	294.40
	20	25.91	68.8	270.70	25.81	70.9	280.10	25.80	69.7	275.20	275.33
	30	25.60	39.6	157.80	26.01	39.1	153.30	25.45	40.4	161.70	157.60
0.5	0	25.65	60.9	241.90	25.50	62.6	250.10	25.70	61.1	242.20	244.73
	10	25.15	54.0	218.70	26.11	56.6	221.00	25.20	55.6	225.10	221.60
	20	25.91	48.5	190.90	25.50	47.8	190.90	25.65	52.5	208.80	196.87
	30	26.57	46.5	178.30	25.80	45.3	179.00	25.30	42.1	169.50	175.60
0.6	0	26.31	32.1	124.30	26.31	32.3	125.00	25.30	44.0	177.10	142.13
	10	28.90	34.4	121.20	26.37	30.7	118.70	26.57	32.8	125.70	121.87
	20	25.70	36.5	144.60	25.80	35.7	141.20	26.06	35.2	137.80	141.20
	30	26.31	21.3	82.70	25.50	21.6	86.30	26.52	22.5	86.60	85.20
0.7	0	26.32	19.9	77.13	25.30	18.0	72.33	26.05	19.2	74.93	74.80
	10	26.42	28.7	110.80	25.05	28.4	115.67	25.50	29.3	117.13	114.53
	20	25.91	21.7	85.33	25.60	20.5	81.80	25.50	21.2	84.87	84.00
	30	25.86	22.9	90.20	25.95	22.6	88.80	25.86	24.2	95.40	91.47

Table I-8 Compressive strength of BFA-Pb-cement mortar with difference percent replacement and w/c ratio at 3-days curing time

w/c ratio	Percent replacement	Specimen number1 Area (cm²)	Specimen number1 Compressive strength kN	Specimen number1 Compressive strength ksc	Specimen number 2 Area (cm²)	Specimen number 2 Compressive strength kN	Specimen number 2 Compressive strength ksc	Specimen number 3 Area (cm²)	Specimen number 3 Compressive strength kN	Specimen number 3 Compressive strength ksc	Mean of compressive strength (ksc)
0.4	0	25.76	71.5	282.80	25.65	70.1	278.60	26.06	73.7	288.20	283.20
	10	26.01	75.2	294.70	25.70	75.4	299.10	25.45	74.2	297.20	297.00
	20	25.30	67.5	271.80	25.30	69.8	281.30	26.06	69.8	272.90	275.33
	30	26.16	41.7	162.60	25.96	40.8	160.10	25.00	40.9	166.90	163.20
0.5	0	25.65	60.9	241.90	25.45	62.4	250.10	26.21	62.3	242.20	244.73
	10	25.35	53.9	216.80	26.21	58.1	225.80	25.15	56.7	229.70	224.10
	20	25.40	49.4	198.30	25.25	48.7	196.80	25.10	51.6	209.70	201.60
	30	26.06	44.5	174.10	26.32	44.0	170.50	25.81	42.9	169.60	171.40
0.6	0	26.16	37.0	144.30	26.16	37.2	145.00	26.26	35.3	137.09	142.13
	10	26.63	31.3	119.90	26.16	30.3	118.00	25.60	32.1	127.70	121.87
	20	25.55	35.9	143.20	25.60	35.4	140.80	25.91	36.2	142.30	142.10
	30	25.45	19.9	79.60	25.30	20.0	80.60	26.36	20.9	81.00	80.40
0.7	0	26.16	19.8	77.13	25.86	18.3	72.33	25.55	18.8	74.93	74.80
	10	26.11	28.8	112.40	26.00	30.0	117.50	25.15	29.0	117.50	115.80
	20	25.80	20.6	81.33	25.75	20.5	81.33	25.40	21.3	85.43	82.70
	30	25.55	22.6	90.33	25.85	22.4	88.40	25.30	18.1	72.97	83.90

Table I-9 Compressive strength of BFA-Cr-cement mortar with difference percent replacement and w/c ratio at 3-days curing time

w/c ratio	Percent replacement	Specimen number1			Specimen number 2			Specimen number 3			Mean of compressive strength (ksc)
		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		Area (cm^2)	Compressive strength		
			kN	ksc		kN	ksc		kN	ksc	
0.4	0	25.70	71.3	282.80	25.96	71.0	278.60	25.96	73.4	288.20	283.20
	10	25.96	76.1	298.80	25.50	72.3	289.00	25.81	78.4	309.50	299.10
	20	25.86	69.5	273.90	25.91	70.0	275.50	25.55	65.5	261.50	270.30
	30	25.60	40.1	159.70	26.01	39.6	155.30	25.45	41.2	165.00	160.00
0.5	0	25.65	60.9	241.90	25.45	62.4	250.10	26.01	61.8	242.20	244.73
	10	25.15	54.7	221.60	26.11	58.5	228.30	25.20	56.2	227.50	225.80
	20	25.40	47.0	188.60	25.55	48.7	194.20	25.10	46.9	190.50	191.10
	30	26.57	44.9	172.20	25.80	44.7	176.80	25.30	44.1	177.80	175.60
0.6	0	26.62	37.4	143.30	26.00	36.2	142.00	25.60	35.4	141.09	142.13
	10	28.90	34.9	123.10	26.37	31.5	121.80	26.57	31.7	121.70	122.20
	20	25.91	36.8	144.60	25.70	35.9	142.30	26.21	36.9	143.70	143.53
	30	26.31	21.4	83.00	25.50	20.3	81.30	26.52	20.6	79.30	81.20
0.7	0	26.37	20.0	77.13	25.60	18.2	72.33	25.85	19.0	74.93	74.80
	10	26.42	29.7	114.50	25.05	27.2	110.80	25.50	26.8	107.10	110.80
	20	26.01	22.2	86.90	26.01	22.5	88.20	26.11	20.3	79.30	84.80
	30	25.86	23.6	93.10	25.95	23.3	91.50	25.86	23.6	93.20	92.60

Appendix J

Regression Analysis

Regression Analysis

1. Definition

The equation may be an empirical model (simple descriptive) or mechanistic model (based on fundamental science). A response variable of dependent variable (y) has been measured at several settings of one or more independent variable (x), also called input variables, regressors, or predictor variable. Regression is the process of fitting an equation to the data. Sometimes, regression is called curve fitting or parameter estimation. Regression analysis is a statistical technique that is very useful for these types of problems (Montgomery, et al., 1997; Taylor and Cihon, 2000; Berthouex and Brown, 2000).

2. Linear Empirical Relationships

Linear relationships are of the form: $Y = a + bX$

Experimenters long have emphasized that the simplest relationship is the one that should be used, and that most often is a straight line. The problem of selection of the function for use is complicated as the number of data points decrease. Data with considerable variability also complicate decision in that apparent curvature can arise due to chance variations (Berthouex and Brown, 2000; Ginevan and Splitstone, 2004).

3. Nonlinear Empirical Relationships

Any data may be fitted with a power series of the proper order. By this is meant an expression of the form: $Y = a + bX + cX^2 + dX^3 + \ldots$

Only the minimum number of power terms necessary to give an acceptable fit should be used. Of course, a perfect fit would be obtained if n data points were fitted with a power series in which the largest exponent was n-1. However, the resulting equation could give strange values at point intermediate to those fitted (Berthouex and Brown, 2000; Ginevan and Splitstone, 2004).

4. Linear and Nonlinear Models

The regression model may be a simple function with one independent variable, or it may have many independent variables with higher-order and nonlinear terms (Kottegoda and Rosso, 1997; Taylor and Cihon, 2000; Berthouex and Brown, 2000), as in the examples given below.

Linear models: $\eta = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_2 x_1 x_2$

Nonlinear models: $\eta = \exp(-\theta x_1)\,(1-x_2)^{\theta}{}_2$

Appendix K

Effect of Buffer on Removal Efficiency

Table K-1 Removal of Pb at different initial concentration and solution pH by bagasse (Bagasse dose 1.0 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature) at 99.50 % Confidence Level

Initial properties of solution		Final properties of solution				% Removal		P-value	Meaning
		No buffer		Add buffer					
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH	No buffer	Add buffer		
10.213	1.02	10.213 ± 0.027	1.05	10.143 ± 0.008	0.99	1.359	2.035	0.013	No diff
39.014	1.01	39.014 ± 0.073	0.97	38.859 ± 0.092	0.98	2.137	2.525	0.083	No diff
99.248	1.00	99.248 ± 0.102	1.00	98.832 ± 0.166	0.99	2.038	2.448	0.021	No diff
10.081	2.01	10.081 ± 0.007	1.94	10.062 ± 0.005	1.98	2.636	2.819	0.018	No diff
38.314	2.02	38.314 ± 0.085	1.96	38.525 ± 0.104	1.98	3.894	3.364	0.053	No diff
97.780	2.01	97.780 ± 0.053	1.97	97.448 ± 0.166	1.99	3.486	3.814	0.030	No diff
7.427	3.02	7.427 ± 0.025	3.01	7.201 ± 0.075	2.99	28.265	30.457	0.007	No diff
36.049	3.00	36.049 ± 0.136	3.01	36.503 ± 0.044	3.01	9.575	8.436	0.005	No diff
87.312	3.00	87.312 ± 0.296	3.02	89.610 ± 0.440	2.98	13.818	11.550	0.011	No diff

Notation: No diff referred to no difference between no buffer and add buffer (P-value > 0.005)

Table K-2 Removal of Pb at different initial concentration and solution pH by bagasse fly ash (Bagasse fly ash dose 0.5 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature) at 99.50 % Confidence Level

Initial properties of solution		Final properties of solution				% Removal		P-value	Meaning
		No buffer		Add buffer					
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH	No buffer	Add buffer		
10.213	1.02	1.597 ± 0.059		1.423 ± 0.040		84.579	86.256	0.014	No diff
39.014	1.01	18.404 ± 0.120		17.908 ± 0.112		53.836	55.080	0.006	No diff
99.248	1.00	91.177 ± 0.317		80.996 ± 0.377		10.003	20.053	3.64E-06	Diff
10.081	2.01	1.101 ± 0.032		1.203 ± 0.034		89.369	88.385	0.020	No diff
38.314	2.02	15.984 ± 0.155		15.334 ± 0.193		59.907	61.536	0.010	No diff
97.780	2.01	77.598 ± 0.337		75.957 ± 0.026		23.407	25.026	0.159	No diff
7.427	3.02	0.404 ± 0.005		0.555 ± 0.040		96.101	94.643	0.761	No diff
36.049	3.00	2.809 ± 0.070		4.052 ± 0.166		92.955	89.837	0.007	No diff
87.312	3.00	9.964 ± 0.185		16.228 ± 0.298		90.165	83.982	0.005	No diff

Notation: No diff referred to no difference between no buffer and add buffer (P-value > 0.005)
Diff referred to difference between no buffer and add buffer (P-value < 0.005)

Table K-3 Removal of Cr at different initial concentration and solution pH by bagasse (Bagasse dose 1.0 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature) at 99.50 % Confidence Level

Initial properties of solution		Final properties of solution				% Removal		P-value	Meaning
		No buffer		Add buffer					
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH	No buffer	Add buffer		
9.997	0.98	8.078 ± 0.016	1.02	7.928 ± 0.035	0.98	19.194	20.693	0.146	No diff
40.231	0.99	32.073 ± 0.050	1.01	32.448 ± 0.044	1.00	20.278	19.346	0.134	No diff
99.794	0.98	83.378 ± 0.528	1.02	82.571 ± 0.341	0.99	16.450	17.258	0.090	No diff
9.997	2.00	8.282 ± 0.007	1.97	8.286 ± 0.010	1.95	17.160	17.110	0.530	No diff
40.231	2.01	33.729 ± 0.038	1.94	33.392 ± 0.012	1.94	16.162	16.999	0.056	No diff
99.794	2.00	86.278 ± 0.092	1.95	86.046 ± 0.179	1.96	13.544	13.776	0.116	No diff
9.997	3.01	8.467 ± 0.008	3.05	8.467 ± 0.011	3.02	15.309	15.303	0.943	No diff
40.231	3.00	34.244 ± 0.057	3.04	34.234 ± 0.027	3.03	14.881	14.907	0.792	No diff
99.794	3.01	86.629 ± 0.068	3.05	86.613 ± 0.209	3.02	13.192	13.208	0.906	No diff

Notation: No diff referred to no difference between no buffer and add buffer (P-value > 0.005)

Table K-4 Removal of Cr at different initial concentration and solution pH by bagasse fly ash (Bagasse fly ash dose 0.5 g/L, volume of sample 50 mL, shaking speed 125 rpm, contact time 60 min and room temperature) at 99.50 % Confidence Level

Initial properties of solution		Final properties of solution				% Removal		P-value	Meaning
		No buffer		Add buffer					
Conc.(mg/L)	pH	Conc.(mg/L) ± SD	pH	Conc.(mg/L) ± SD	pH	No buffer	Add buffer		
9.997	0.98	2.949 ± 0.021	1.01	2.950 ± 0.024	1.00	70.500	70.496	0.983	No diff
40.231	0.99	29.008 ± 0.187	1.01	29.034 ± 0.061	1.00	27.895	27.832	0.834	No diff
99.794	0.98	83.227 ± 0.377	1.02	82.858 ± 0.171	0.99	16.601	16.971	0.198	No diff
9.997	2.00	3.746 ± 0.045	2.07	3.704 ± 0.023	2.04	62.525	62.949	0.220	No diff
40.231	2.01	29.637 ± 0.043	2.06	29.647 ± 0.063	2.05	26.332	26.309	0.842	No diff
99.794	2.00	87.118 ± 0.353	2.08	87.114 ± 0.270	2.04	12.702	12.706	0.988	No diff
9.997	3.01	6.945 ± 0.101	3.09	6.788 ± 0.007	3.06	30.530	32.097	0.056	No diff
40.231	3.00	33.751 ± 0.054	3.08	33.316 ± 0.069	3.05	16.108	17.189	0.057	No diff
99.794	3.01	90.442 ± 0.220	3.08	89.595 ± 0.102	3.05	9.372	10.220	0.079	No diff

Notation: No diff referred to no difference between no buffer and add buffer (P-value > 0.005)

Appendix L

Langmuir-Hinshelwood model

(Missen, et al., 1999, and Satterfield, 1993)

Langmuir-Hinshelwood model

Correlations of rate data may be sought for any of several purposes. The process engineer may wish to develop a model for a specific reaction so as to be able to predict the effect of reactor operating changes on performance. A study of the detailed kinetics of one particular reaction has been a traditional approach to obtaining some understanding, even though indirect, of its mechanism. Regardless of the objective, the investigator desires a mathematical model to represent the data.

The true mechanism in all step of reaction is not known for even the simplest reaction. The closer a model reflects actuality, of course, the more reliable it is, but an attempt to allow for the complex nature of a heterogeneous reaction may easily lead to a complicated formulation containing many parameters that must be empirically adjusted. In this event the model loses theoretical justification. If an industrial reaction proceeds by a complex and little-known mechanism, the process engineer may find it adequate to use an essentially empirical correlation.

In many cases the rate of reaction of one or more chemisorbed species appears to be the rate-limiting step, rather than rate of adsorption or desorption as such. The kinetic formulations based on this assumption usually bear the term Langmuir-Hinshelwood. The assumptions underlying the Langmuir adsorption isotherm (adsorption without reaction) are retained. The assumptions are:

1. The adsorbed species are held onto definite points of attachment on the surface. (This implies that the maximum adsorption possible corresponds to a monolayer). Each site can accommodate only one adsorbed species.

2. The differential energy of adsorption is independent of surface coverage. (This implies that the surface is completely uniform so that there is the same probability of adsorption on all sites. A further implication is that adsorbed molecules are localized). Attractive or repulsive forces between adjacent adsorbed molecules and taken to be negligible, so the energy of an adsorbed species or the probability of

adsorption onto an empty site are independent of whether or not an adjacent site is occupied.

Langmuir-Hinshelwood is separated to 5 cases namely; 1) decomposition, products not adsorbed, 2) Decomposition, products adsorbed, 3) Bimolecular reaction, 4) Adsorption/Desorption with dissociation, and 5) adsorption of two gasses on separate sites. However, the reaction of this research associated with first case. The detail of case decomposition, products not adsorbed as follow:

The concentrations of adsorbed species are therefore determined by adsorption equilibira as given by the Langmiur isotherm. Reaction is assumed to occur between adsorbed species on the catalyst. If a single reactant is decomposed, the process may be assumed to be either unimolecular or bimolecular, depending on the number of product molecules formed per reactant molecule and whether or not the products are adsorbed. In case 1, a simple decomposition in which products are not adsorbed is usually taken to be unimolecular.

Case 1: Decomposition, Products not adsorbed

A kinetics scheme for an overall reaction expressed as

$$A(g) \longrightarrow B(g)$$

Where A is a gas-phase reactant and B a gas-phase product, is as follows:

$$A(g) \xrightarrow{k_{Ag}} A(\text{surface vicinity});\ \text{mass transfer (fast)} \quad (1)$$

$$A(\text{surface vicinity}) + s \Leftrightarrow A\bullet s;\ \text{adsorption-desorption (fast)} \quad (2)$$

$$A\bullet s \xrightarrow{k} B(\text{surface vicinity}) + s;\ \text{surface reaction (slow)} \quad (3)$$

$$B(\text{surface vicinity}) \xrightarrow{k_{Bg}} B(g);\ \text{mass transfer (fast)} \quad (4)$$

Here A(g) and B(g) denote reactant and product, k_{Ag} and k_{Bg} are mass-transfer coefficients, s is an adsorption site, and A•s is a surface-reaction intermediate. In this scheme, it is assumed that B is not adsorbed.

The reaction rate is taken to be proportional to the quantity of adsorbed A molecules. Then,

$$-r \text{ (moles) / (time)(area)} = k\theta_A$$

where θ_A is the fraction of the surface covered by adsorbed species A. The value of θ_A is given by the Langmuir adsorption isotherm:

$$\theta_A = KP_A / 1 + KP_A$$

Combining these two equations,

$$-r = kKP_A / 1 + KP_A$$

If the system follows this model, the reaction rate should be first order at sufficiently low values of P_A. As P_A increase, the order of reaction should gradually drop and become zero order. Similarly, the reaction rate should be first order if A is weakly adsorbed-for example, K is small-and zero order if A is strongly adsorbed. This type of behavior is indeed found for a number of decompositions.

Appendix M

Isotherm Equation Analysis at Difference solution pH and initial Pb concentration

Table M-1 Adsorption isotherm equation data for removal Pb by bagasse at difference solution pH and initial Pb concentration.

pH	Co (mg/L)	Ce (mg/L)	x (mg/L)	q (mg/g)	1/Ce	1/q	log Ce	log q
1.02	4.916	4.889	0.027	0.003	0.205	369.850	0.689	-2.568
1.01	10.610	10.434	0.176	0.018	0.096	56.778	1.018	-1.754
1.02	20.508	20.157	0.351	0.035	0.050	28.515	1.304	-1.455
1.02	30.125	29.580	0.545	0.055	0.034	18.340	1.471	-1.263
1.05	41.130	40.077	1.053	0.105	0.025	9.497	1.603	-0.978
1.02	80.620	78.846	1.774	0.177	0.013	5.638	1.897	-0.751
2.05	4.916	4.786	0.130	0.013	0.209	76.761	0.680	-1.885
2.03	10.610	10.319	0.291	0.029	0.097	34.398	1.014	-1.537
2.08	20.508	19.962	0.546	0.055	0.050	18.331	1.300	-1.263
2.02	30.125	29.269	0.856	0.086	0.034	11.688	1.466	-1.068
2.03	41.130	39.929	1.201	0.120	0.025	8.326	1.601	-0.920
2.02	80.620	77.919	2.701	0.270	0.013	3.703	1.892	-0.569
3.04	4.916	3.358	1.558	0.156	0.298	6.417	0.526	-0.807
3.16	10.610	7.216	3.394	0.339	0.139	2.946	0.858	-0.469
3.04	20.508	17.865	2.643	0.264	0.056	3.783	1.252	-0.578
3.00	30.125	27.179	2.946	0.295	0.037	3.394	1.434	-0.531
3.04	41.130	37.947	3.183	0.318	0.026	3.141	1.579	-0.497
3.01	80.620	72.171	8.449	0.845	0.014	1.184	1.858	-0.073
4.06	4.916	1.737	3.179	0.318	0.576	3.146	0.240	-0.498
4.04	10.610	5.299	5.311	0.531	0.189	1.883	0.724	-0.275
4.05	20.508	13.133	7.375	0.737	0.076	1.356	1.118	-0.132
4.01	30.125	21.075	9.050	0.905	0.047	1.105	1.324	-0.043
4.05	41.130	29.334	11.796	1.180	0.034	0.848	1.467	0.072
4.03	80.620	66.052	14.568	1.457	0.015	0.686	1.820	0.163
5.05	4.916	1.040	3.876	0.388	0.961	2.580	0.017	-0.412
5.03	10.610	2.481	8.129	0.813	0.403	1.230	0.395	-0.090
5.03	20.508	7.395	13.113	1.311	0.135	0.763	0.869	0.118
5.06	30.125	13.484	16.641	1.664	0.074	0.601	1.130	0.221
5.01	41.130	20.429	20.701	2.070	0.049	0.483	1.310	0.316
5.03	80.620	49.501	31.119	3.112	0.020	0.321	1.695	0.493
6.03	4.916	0.237	4.679	0.468	4.220	2.137	-0.625	-0.330
5.97	10.610	1.856	8.754	0.875	0.539	1.142	0.269	-0.058
6.03	20.508	4.573	15.935	1.593	0.219	0.628	0.660	0.202
6.04	30.125	8.396	21.729	2.173	0.119	0.460	0.924	0.337
6.03	41.130	13.256	27.874	2.787	0.075	0.359	1.122	0.445
6.02	80.620	27.669	52.951	5.295	0.036	0.189	1.442	0.724

Table M-2 Adsorption isotherm equation data for removal Pb by bagasse fly ash at difference solution pH and initial Pb concentration.

pH	Co (mg/L)	Ce (mg/L)	x (mg/L)	q (mg/g)	1/Ce	1/q	log Ce	log q
1.02	5.448	0.424	5.024	0.502	2.358	1.990	-0.373	-0.299
2.02	5.448	1.800	10.180	1.018	0.556	0.982	0.255	0.008
3.01	5.448	5.154	14.876	1.488	0.194	0.672	0.712	0.172
4.02	5.448	10.492	19.563	1.956	0.095	0.511	1.021	0.291
5.01	5.448	19.702	23.428	2.343	0.051	0.427	1.295	0.370
6.00	5.448	62.384	18.236	1.824	0.016	0.548	1.795	0.261
1.05	11.980	0.282	5.166	0.517	3.546	1.936	-0.550	-0.287
2.00	11.980	1.494	10.486	1.049	0.669	0.954	0.174	0.021
3.00	11.980	4.790	15.240	1.524	0.209	0.656	0.680	0.183
4.03	11.980	9.135	20.920	2.092	0.109	0.478	0.961	0.321
5.02	11.980	17.249	25.881	2.588	0.058	0.386	1.237	0.413
6.02	11.980	58.130	22.490	2.249	0.017	0.445	1.764	0.352
1.02	20.030	ND	NC	NC	NC	NC	NC	NC
2.01	20.030	0.809	11.171	1.117	1.236	0.895	-0.092	0.048
3.00	20.030	1.441	18.589	1.859	0.694	0.538	0.159	0.269
4.01	20.030	2.763	27.292	2.729	0.362	0.366	0.441	0.436
5.03	20.030	4.427	38.703	3.870	0.226	0.258	0.646	0.588
6.01	20.030	13.545	67.075	6.708	0.074	0.149	1.132	0.827
1.02	30.055	ND	NC	NC	NC	NC	NC	NC
2.02	30.055	0.267	11.713	1.171	3.745	0.854	-0.573	0.069
3.01	30.055	0.708	19.322	1.932	1.412	0.518	-0.150	0.286
4.00	30.055	1.272	28.783	2.878	0.786	0.347	0.105	0.459
5.05	30.055	1.986	41.144	4.114	0.504	0.243	0.298	0.614
6.04	30.055	8.805	71.815	7.182	0.114	0.139	0.945	0.856
1.01	43.130	ND	NC	NC	NC	NC	NC	NC
2.02	43.130	ND	NC	NC	NC	NC	NC	NC
3.02	43.130	0.442	19.588	1.959	2.262	0.511	-0.355	0.292
4.03	43.130	0.816	29.239	2.924	1.226	0.342	-0.088	0.466
5.00	43.130	1.389	41.741	4.174	0.720	0.240	0.143	0.621
6.01	43.130	3.915	76.705	7.671	0.255	0.130	0.593	0.885
1.00	80.620	ND	NC	NC	NC	NC	NC	NC
2.02	80.620	ND	NC	NC	NC	NC	NC	NC
3.01	80.620	0.312	19.718	1.972	3.205	0.507	-0.506	0.295
4.00	80.620	0.586	29.469	2.947	1.707	0.339	-0.232	0.469
5.04	80.620	1.059	42.071	4.207	0.944	0.238	0.025	0.624
6.03	80.620	1.471	79.149	7.915	0.680	0.126	0.168	0.898

ND referred to non detection (less than detection limit of equipment)

NC referred to can not calculation

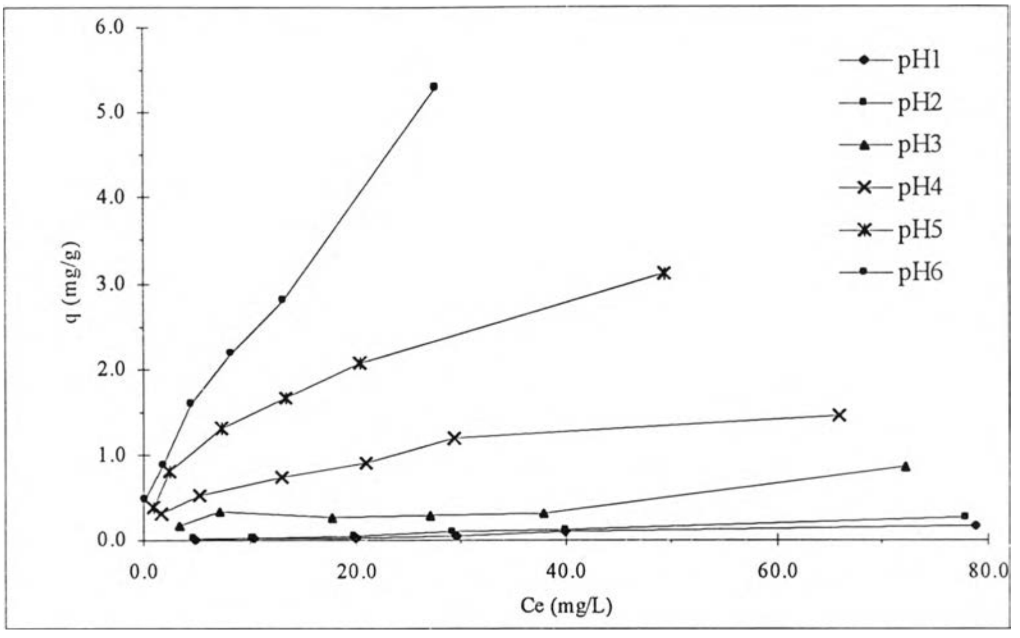


Figure M.1 Isotherm for removal of Pb(II) onto Bagasse at difference solution pH

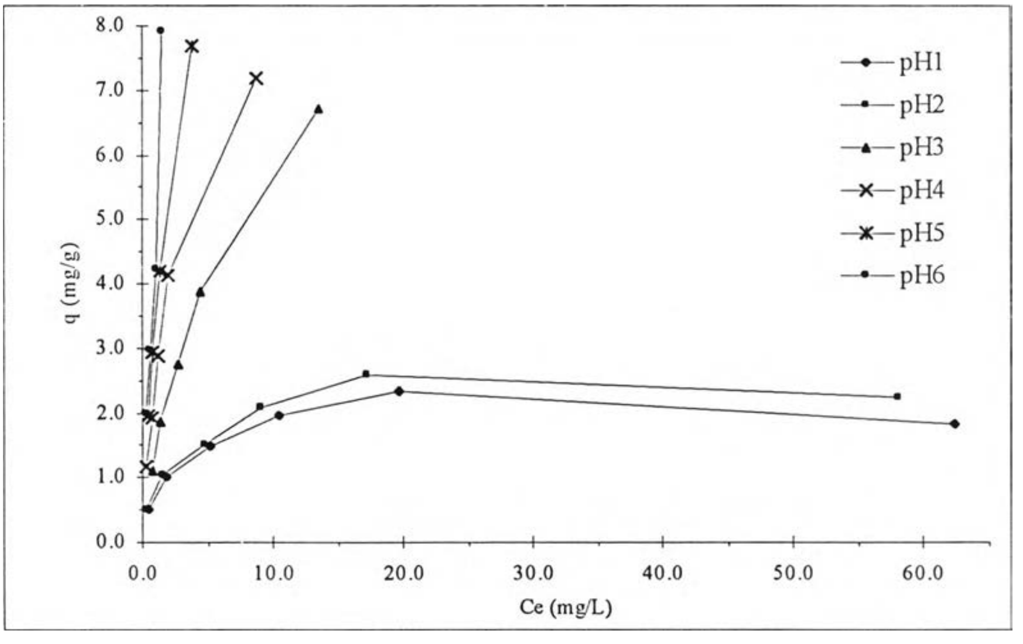
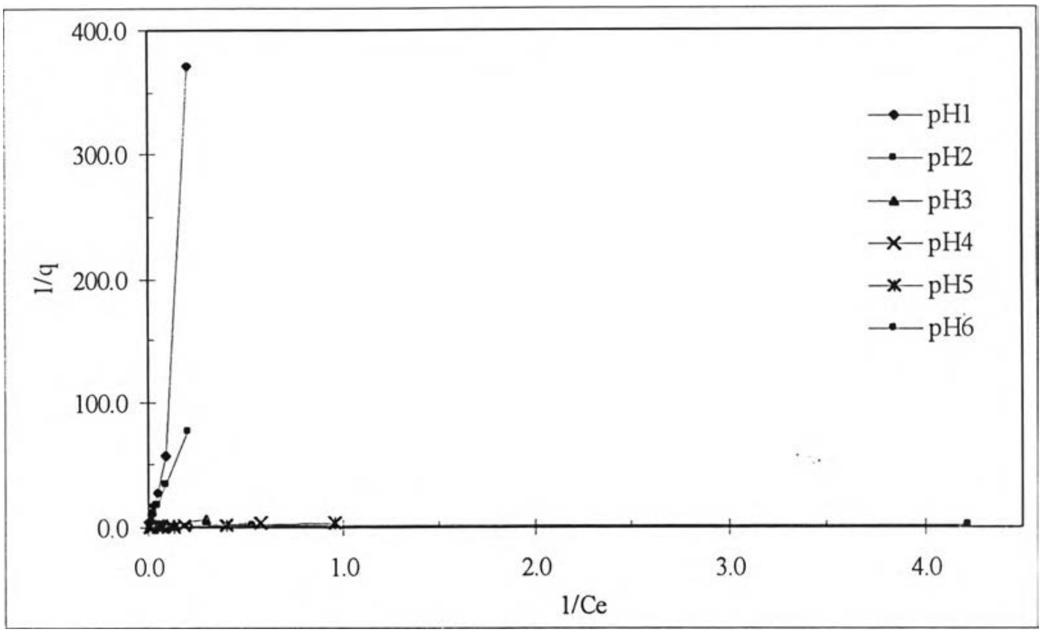
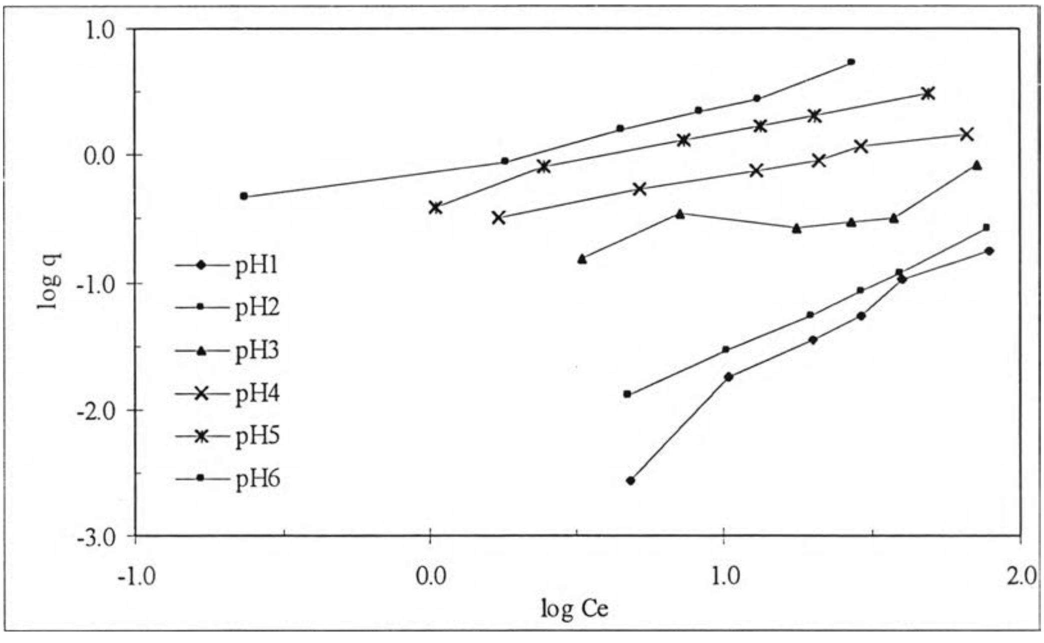


Figure M.2 Isotherm for removal of Pb(II) onto Bagasse fly ash at difference solution pH

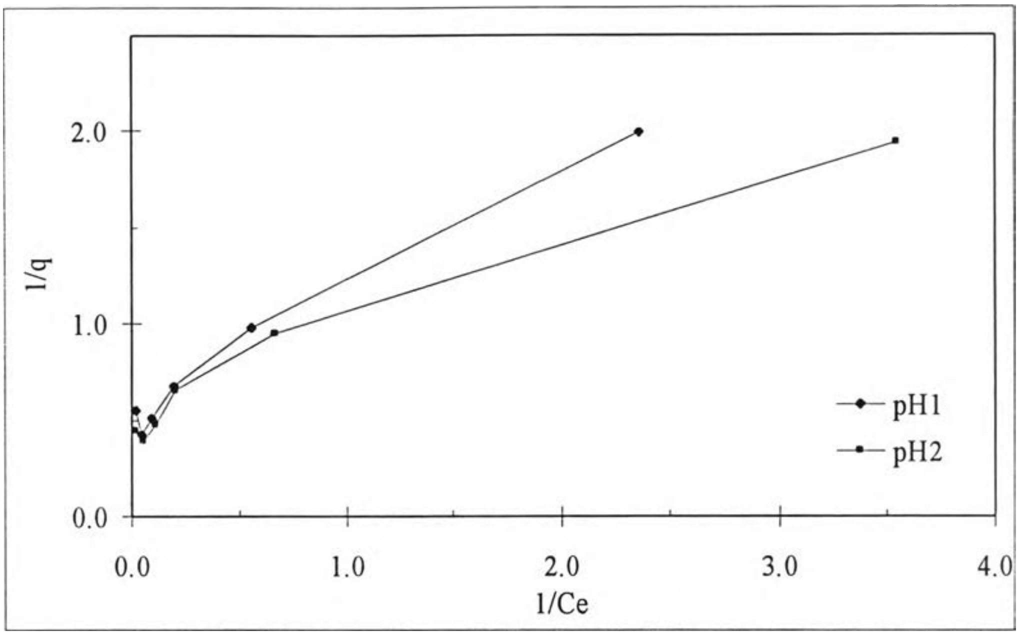


(a)

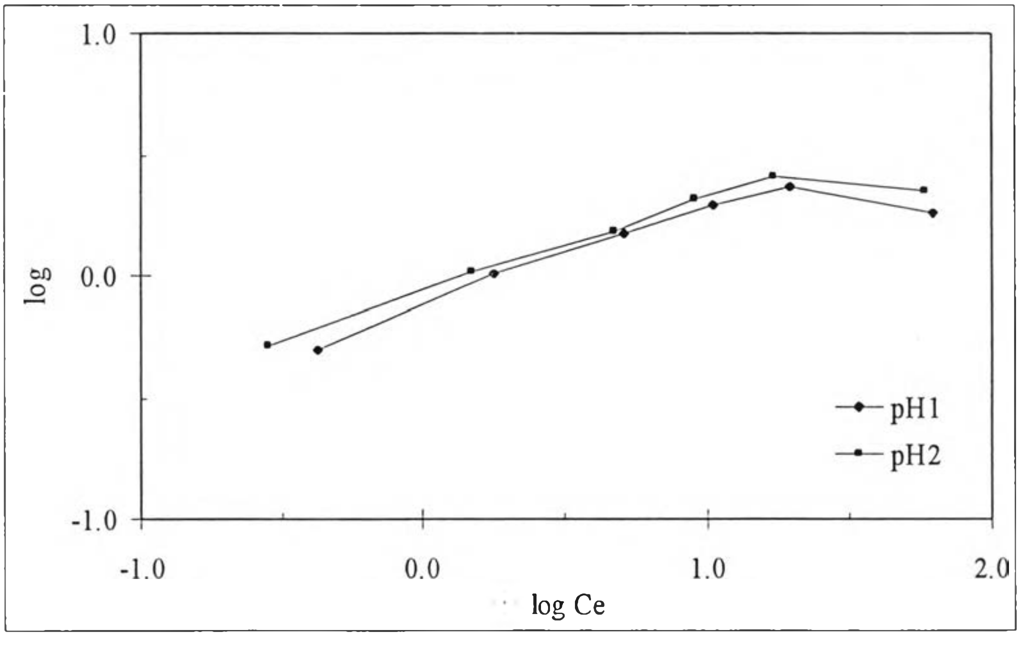


(b)

Figure M.3 Linearized (a) Langmuir and (b) Freundlich Isotherm of Pb(II) onto Bagasse



(a)



(b)

Figure M.4 Linearized (a) Langmuir and (b) Freundlich Isotherm of Pb(II) onto Bagasse Fly Ash

BIOGRAPHY

Miss Sirawan Ruangchuay obtained her B.Sc. degree from Silpakorn University in the faculty of science in 1994. Her major study was Environmental Science. And she received her M.Sc. degree in Environmental Technology from King Mongkut University of Technology Thonburi in 1999. After that, she was lecturer at Suan Dusit Rajaphat University from 1999 until now. She pursued her Doctor Degree studies in Inter-Department of Environmental Management, Chulalongkorn University, Bangkok, Thailand in May 2002. She finished her Doctor Degree of Philosophy in Environmental Management in October 2005.