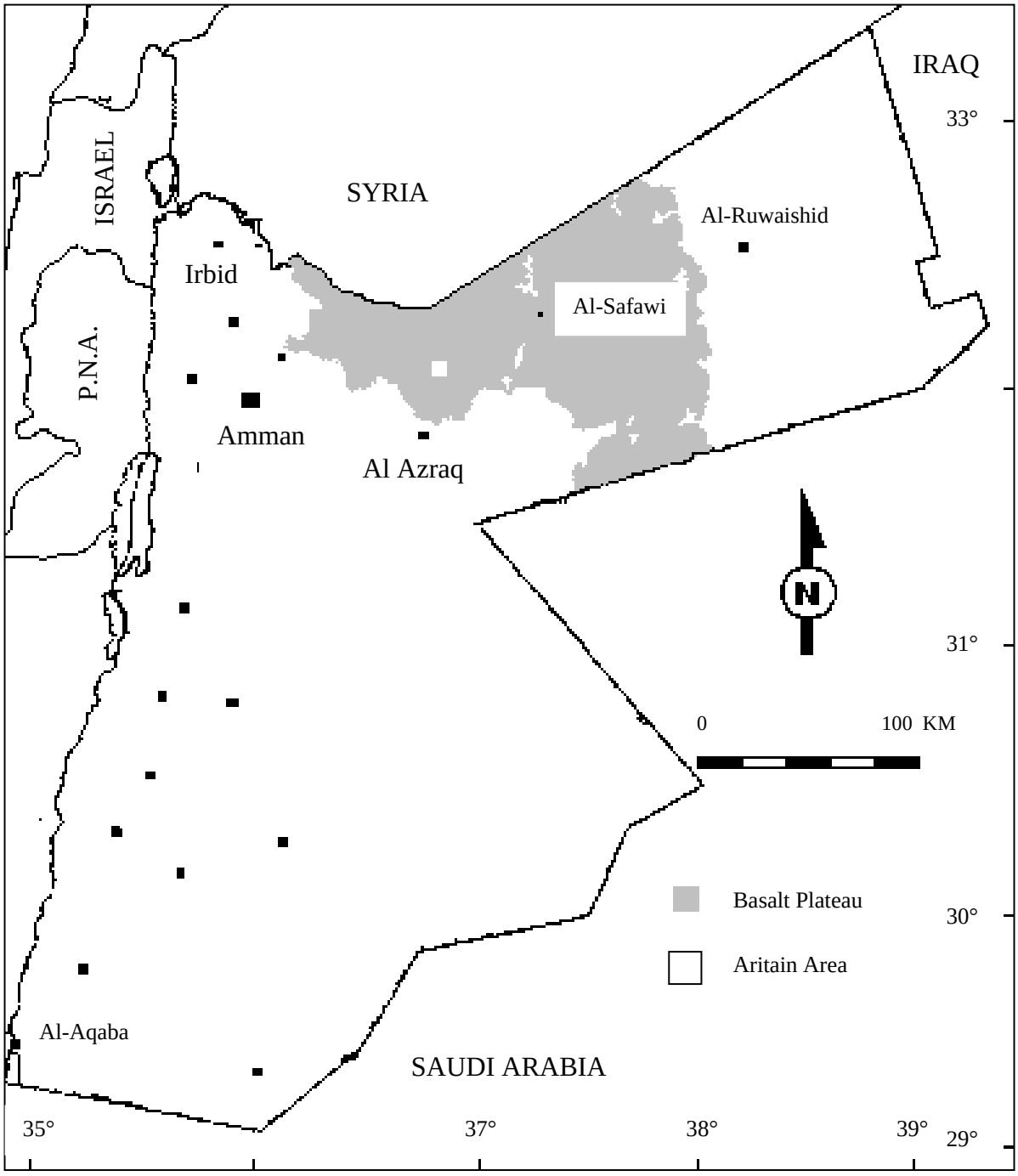
Appendices

Appendix 1

1.1 Location map of Aritain area



Appendix 2

2.1 The maximum values of some pollutants concentrations (mg/l) which are allowed in the discharged industrial wastewater effluent (after the Jordanian standards number 202/1990, personal contact with ministry of water and irrigation).

	Reuse purpose of the treated wastewater		
Type of pollutants	Agricultural reuse	Ground water recharge	Discharge to the surface water reservoirs
BOD5	-	50	50
COD	-	150	150
NO_3^--N	30	12*	12*
NH_3	5	5	5
TKN-N	50		
PO_4^{3-}-P	-	-	15
Na^+	-	400	-
Mg^{2+}	-	-	-
Ca^{2+}	-	-	-
Pb^{2+}	1	0.1	0.1
Cd^{2+}	0.01	0.02	0.01
Total Cu^{2+}	0.2	2	2
Ni^{2+}	0.2	0.1	0.2
Zn^{2+}	2	15	15

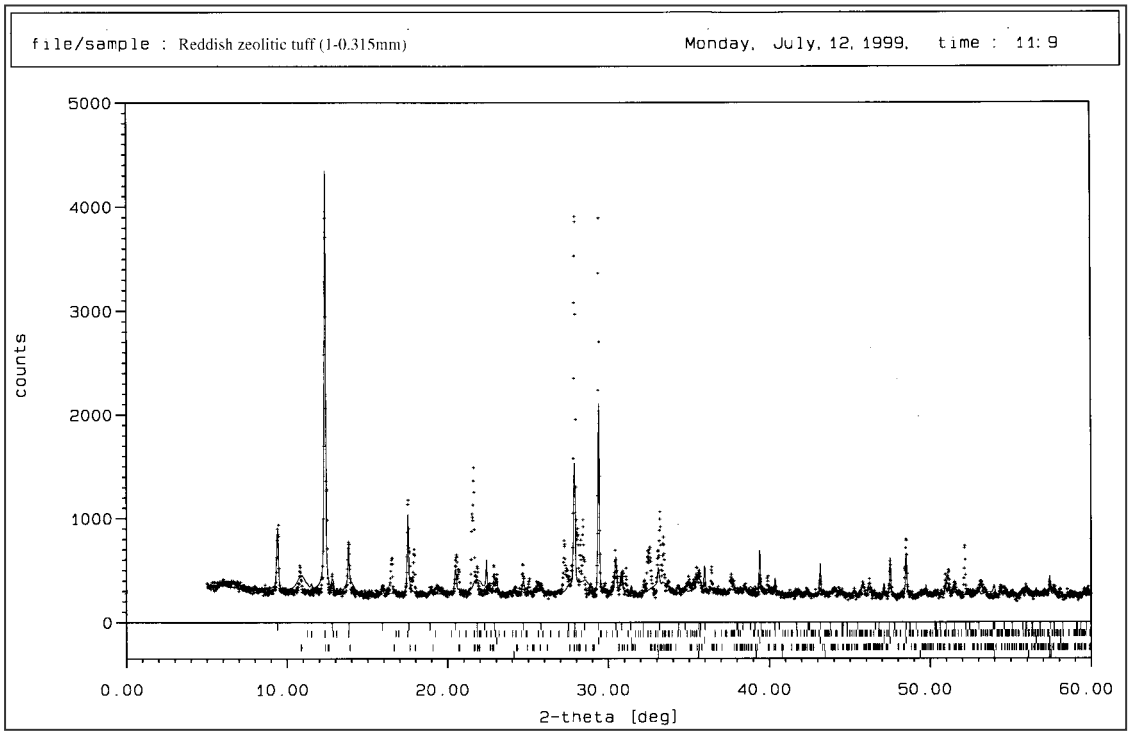
*Depends on their concentration in the received water reservoir.

Appendix 3

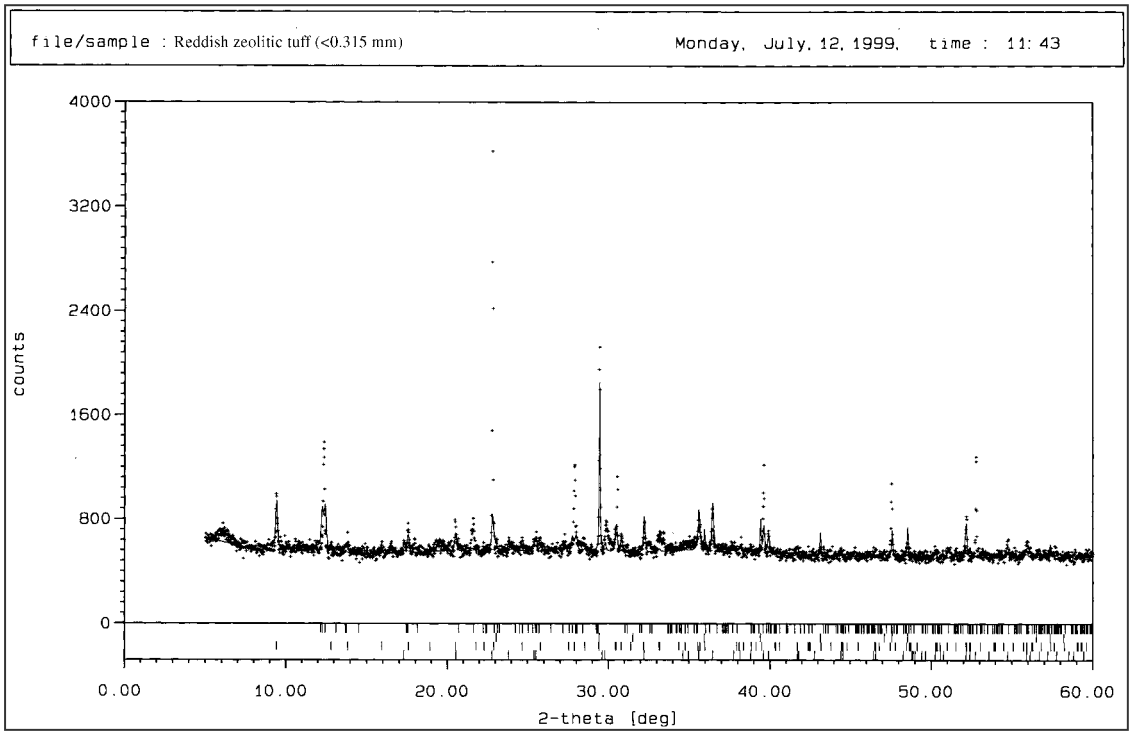
3.1 X-ray diffraction diagrams of Jordanian zeolitic tuffs

(Diffractometer: Phillips X'Pert Alph-1, CuKα, Sample porter 26 mm, radiation width 15 mm)

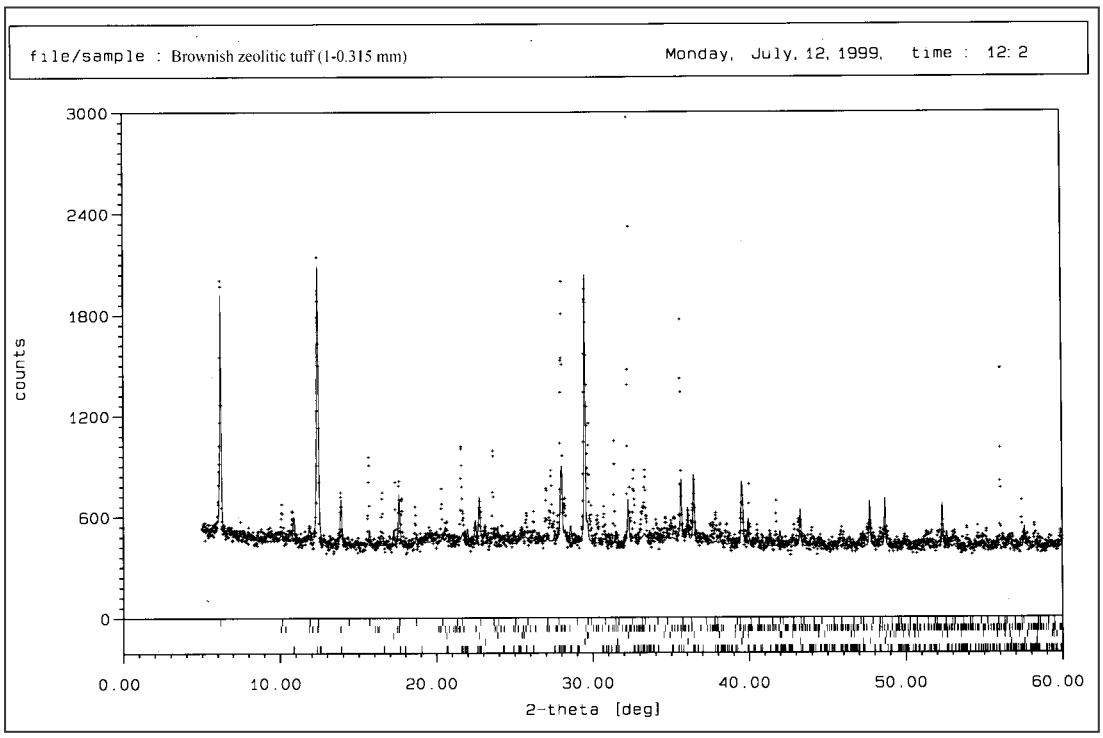
a. Resddish zeolitic tuff (1-0.315 mm)



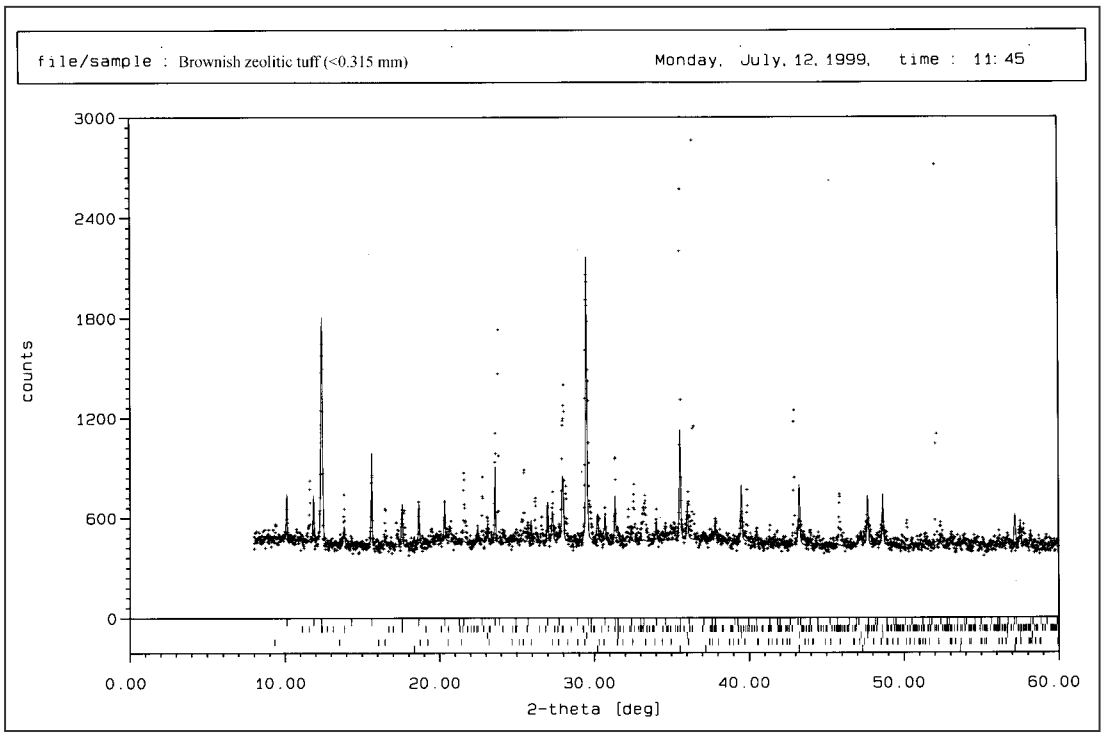
b. Reddish zeolitic tuff (<0.315 mm)



c. Brownish zeolitic tuff (1-0.315 mm)



d. Brownish zeolitic tuff (<0.315 mm)



3.2 Weight lost (%) of zeolitic tuffs after the treatment by heating for 4 hrs.

	Reddish zeolitic tuff		Brownish zeolitic tuff	
Temperature °C	1-0.315mm	-0.315mm	1-0.315mm	-0.315mm
150	8.40	6.60	4.70	2.10
200	9.30	6.20	6.00	3.90
250	8.80	5.20	5.00	1.90
300	10.8	7.50	6.30	5.90
350	8.70	7.10	7.30	6.50
400	11.0	7.30	7.60	5.30
500	10.4	9.30	8.20	5.60
600	13.0	8.80	11.5	6.40
700	13.3	11.9	14.6	15.0
800	17.1	12.3	14.7	11.6
900	17.5	13.0	14.7	16.2

3.3 Water gain (%) after cooling the, previously heated, zeolitic tuffs at room temperature for 24 hrs.

	Reddish zeolitic tuff		Brownish zeolitic tuff	
Temperature °C	1-0.315mm	-0.315mm	1-0.315mm	-0.315mm
150	9.70	8.50	9.50	8.60
200	10.0	8.10	10.5	8.90
250	8.00	7.40	9.00	8.30
300	4.70	5.20	8.00	7.10
350	9.60	8.00	8.50	9.20
400	4.40	4.70	8.10	5.60
500	4.20	4.90	7.60	5.60
600	3.80	4.60	6.60	5.00
700	3.10	3.20	6.60	3.80
800	3.20	1.50	5.50	3.90
900	0.80	1.80	0.90	1.10

3.4 The effect of heat regeneration on the adsorption amount of NH_3 and H_2O on the 1-0.315 mm grain size zeolitic tuffs from a gas stream.

	Reddish zeolitic tuff		Brownish zeolitic tuff	
Temperature °C	NH_3 (mg/100g)	H_2O (%)	NH_3 (mg/100g)	H_2O (%)
105	21.0	5.77	20.0	8.72
150	20.0	5.50	52.0	8.47
200	39.0	7.37	61.0	7.88
250	40.0	6.92	74.0	10.3
300	20.0	1.97	63.0	6.20
400	12.0	2.25	53.0	5.80
500	11.0	2.10	11.0	7.13
600	8.0	1.35	10.0	4.55
700	9.0	1.31	3.0	4.40
800	1.00	0.00	3.0	2.65

Appendix 4

4.1 Adsorbed /desorbed Ca^{2+} ions from the NH_4^+-zeolitic tuffs after their treatment by using tap water.

Wash number	The weight of zeolitic tuff used (g)					
	0.5 RZT	1 RZT	1.5 RZT	0.5 BZT	1 BZT	1.5 BZT
W1	18	20	20	10	14	18
W2	40	45	45	29	38	42
W3	7	24	28	3	9	18
W4	7	17	23	-4	3	13
W5	10	16	27	6	16	10
W6	6	8	17	3	0	5
W7	-8	-4	8	0	1	2
W8	-2	0	7	2	2	1
W9	10	10	13	8	13	9
W10	-11	-2	-3	-7	-4	-4
W11	-2	3	4	7	-1	6
W12	-1	0	-6	-3	-7	-4
W13	0	6.4	6	-3	2	2
W14	5	1	-1	0	-1	2
W15	-3	-11	-3	-12	-4	-5
W16	-17	2	5	4	8	1
W17	3	4	3	6	7	-5
W18	12	17	12	0	8	12
W19	10	10	11	3	14	4
W20	7	7	7	4	0	-4
W21	-3	-1	-2	-11	-6	-12
W22	2	2	3	0	-2	-2
W23	2	2	2	0	0	-1

4.2 Adsorbed /desorbed Mg^{2+} ions from the NH_4^+-zeolitic tuffs after their treatment by using tap water.

Wash number	The weight of zeolitic tuff used (g)					
	0.5 RZT	1 RZT	1.5 RZT	0.5 BZT	1 BZT	1.5 BZT
W1	-2	-1	0	-1	-2	0
W2	2	3	3	3	3	4
W3	0	-2	0	-1	-1	-2
W4	-2	-1	-1	-1	-1	1
W5	1	1	0	1	2	0
W6	0	0	1	1	0	-1
W7	0	0	1	1	0	0
W8	0	0	-1	0	-1	0
W9	-2	1	-1	1	0	0
W10	0	1	0	0	-1	0
W11	0	1	-1	1	1	1
W12	1	1	1	1	1	1
W13	-1	2	1	1	1	1
W14	-2	0	1	1	-1	0
W15	0	-2	-1	-2	-1	-2
W16	-2	0	-1	1	0	0
W17	-1	-2	-2	-2	-3	-3
W18	0	-1	-1	1	-1	-1
W19	0	1	-1	1	1	0
W20	-1	0	0	-1	0	-1
W21	0	0	0	-1	-1	-1
W22	-1	0	1	1	0	0
W23	-1	-1	-1	-1	-1	0

4.3 Adsorbed /desorbed Na^+ ions from the NH_4^+-zeolitic tuffs after their treatment by using tap water.

Wash number	The weight of zeolitic tuff used (g)					
	0.5 RZT	1 RZT	1.5 RZT	0.5 BZT	1 BZT	1.5 BZT
W1	-2	2	4	-4	-4	-1
W2	6	7	9	6	6	6
W3	0	-1	1	0	1	1
W4	-6	-7	-7	-5	-6	-6
W5	3	2	0	2	5	2
W6	0	0	-1	0	1	0
W7	0	0	0	1	1	1
W8	0	-1	0	0	0	0
W9	4	4	4	2	2	3
W10	-1	0	0	-1	-1	0
W11	2	2	1	2	0	3
W12	-2	-2	-1	-3	-3	-3
W13	1	1	0	0	0	0
W14	-2	-1	-3	-3	-3	-3
W15	-7	-1	-1	-7	-1	-2
W16	0	0	0	-1	-1	-1
W17	-2	1	2	-2	-2	-2
W18	1	2	2	-1	0	0
W19	1	2	2	1	1	1
W20	-4	-4	-4	-6	-6	-6
W21	1	2	2	-1	-3	-3
W22	-1	-2	-1	-1	-1	-1
W23	-1	-1	-1	-1	-1	-2

- RZT and BZT represente reddish and brownish zeolitic tuff respectively.

4.4 Adsorbed amount of ammonium (mg) in relation to the amount of zeolitic tuffs added and the contact time

Amount and type of zeolitic tuff added	Agitation time (days)				
	1	2	3	4	5
1g Reddish zeolitic tuff	1	1	2	3	2
2g Reddish zeolitic tuff	8	3	5	6	5
3g Reddish zeolitic tuff	18	3	9	6	6
4g Reddish zeolitic tuff	15	5	13	9	12
5g Reddish zeolitic tuff	18	12	20	6	15
1g Brownish zeolitic tuff	4	2	4	5	1
2g Brownish zeolitic tuff	12	5	8	8	4
3g Brownish zeolitic tuff	16	6	9	11	6
4g Brownish zeolitic tuff	17	8	11	12	8
5g Brownish zeolitic tuff	25	9	19	15	10

4.5 Adsorption-desorption amount (in mg) of counter cations.

Amount of zeolitic tuff added	Adsorbed-desorbed cations (mg)									
	Reddish Zeolitic tuff					Brownish zeolitic tuff				
Agitated for 1 day	Mg^{2+}	Ca^{2+}	Na^{+}	K^{+}	Tot.	Mg^{2+}	Ca^{2+}	Na^{+}	K^{+}	Tot.
1g	0	2	-1	2	3	0	4	-4	5	5
2g	0	5	-3	8	10	-1	4	-5	7	5
3g	0	2	-6	11	7	0	4	-9	14	9
4g	-1	-1	-8	15	5	0	-6	-12	18	0
5g	-1	-3	-11	16	1	-1	1	-13	22	9
Agitated for 2 days										
1g	0	-1	-4	-7	-12	-1	-1	-5	-13	-20
2g	0	-2	-6	-13	-21	-1	-2	-8	-1	-12
3g	-1	-5	-9	-1	-16	-2	-5	-11	3	-15
4g	-1	-5	-9	14	-1	-1	-3	-13	11	-6
5g	-3	-7	-13	3	-20	-2	-4	-16	15	-7
Agitated for 3 days										
1g	0	-5	-3	-4	-12	0	0	-3	6	3
2g	0	-2	-5	0	-7	0	-2	-7	8	-1
3g	0	-2	-7	6	-3	-1	-4	-8	10	-3
4g	-1	-10	-10	8	-13	-1	-3	-11	16	1
5g	0	-8	-11	10	-9	-1	-1	-12	12	-2
Agitated for 4 days										
1g	-1	-16	-6	-4	-27	-1	-16	-6	-4	-27
2g	-1	-10	-7	-4	-22	-2	-9	-8	-2	-21
3g	-2	-9	-9	7	-13	-1	-16	-11	1	-27
4g	-2	-10	-12	3	-21	-2	-2	-10	18	4
5g	-2	-12	-14	11	-17	-1	-9	-14	11	-13
Agitated for 5 days										
1g	1	4	-2	-3	0	0	-5	-4	4	-5
2g	0	1	-4	6	3	2	1	-8	14	9
3g	0	1	-6	8	3	0	3	-8	18	13
4g	-1	-1	-9	6	-5	0	2	-11	22	13
5g	0	-2	-10	22	10	0	1	-15	22	8

4.6 Concentrations of cations eluted from previously agitated zeolitic tuff with the manure by adding of distilled (*) or tap water (mg/l).

a. Ca^{2+} ions

Wash number	Reddish Zeolitic tuff					Brownish zeolitic tuff				
	1g*	1g	1.5g	2g	2.5g	1g*	1g	1.5g	2g	2.5g
W1	0	27	31	35	34	1	26	30	31	33
W2	1	25	24	29	31	2	20	24	23	27
W3	2	-6	5	3	6	2	1	-1	-4	4
W4	2	1	3	9	8	3	3	6	2	8
W5	3	10	9	7	9	3	7	9	9	8
W6	2	14	28	19	30	2	12	22	26	28
W7	0	-3	2	-4	6	8	-6	1	4	-2
W8	0	3	1	-1	7	2	2	-3	-2	5
W9	1	7	3	0	3	3	-6	1	-7	5
W10	0	5	-2	2	2	2	6	0	-6	8

b. Mg^{2+} ions

Wash number	Reddish Zeolitic tuff					Brownish zeolitic tuff				
	1g*	1g	1.5g	2g	2.5g	1g*	1g	1.5g	2g	2.5g
W1	1	2	2	2	2	0	2	3	4	5
W2	1	1	0	0	1	1	0	1	1	3
W3	1	-1	-1	0	0	1	0	0	1	2
W4	1	0	0	0	-1	1	0	-1	0	0
W5	1	1	3	1	1	1	1	2	2	1
W6	0	0	0	1	0	1	1	0	1	0
W7	1	-1	0	-2	2	1	1	1	1	1
W8	1	3	1	3	1	0	1	1	1	3
W9	2	3	2	1	1	1	1	1	1	2
W10	3	3	2	2	2	1	2	2	3	2

c. Na^+ ions

Wash number	Reddish Zeolitic tuff					Brownish zeolitic tuff				
	1g*	1g	1.5g	2g	2.5g	1g*	1g	1.5g	2g	2.5g
W1	4	-5	-7	-9	-11	5	-5	-8	-10	-12
W2	3	-2	-5	-6	-6	3	-3	-4	-5	-5
W3	2	0	-1	-1	-2	2	0	-1	-1	-1
W4	2	1	0	0	-1	1	0	0	0	0
W5	21	1	1	0	1	1	1	0	1	1
W6	1	0	1	0	0	1	0	1	1	1
W7	1	-1	-1	-2	-1	1	0	-1	0	-1
W8	1	-1	-1	0	0	0	0	0	0	0
W9	1	2	3	4	1	1	1	1	1	2
W10	2	1	-2	-2	-2	3	-2	-1	1	-2

d. K^+ ions

Wash number	Reddish Zeolitic tuff					Brownish zeolitic tuff				
	1g*	1g	1.5g	2g	2.5g	1g*	1g	1.5g	2g	2.5g
W1	10	-28	-35	-41	-47	15	-38	-49	-52	-55
W2	9	-17	-27	-31	-33	12	-19	-27	-34	-38
W3	7	-9	-12	-15	-18	7	-7	-12	-17	-21
W4	6	-6	-9	-11	-14	6	-7	-10	-15	-18
W5	6	-6	-8	-10	-12	5	-4	-6	-11	-15
W6	5	-5	-7	-9	-11	5	-4	-6	-8	-10
W7	6	-5	-7	-11	-11	10	-3	-5	-7	-9
W8	4	-5	-6	-8	-10	3	-3	-5	-7	-8
W9	4	-3	-4	-10	-8	3	-2	-4	-5	-5
W10	3	-3	-7	1	-2	6	-4	-5	-4	-5

Appendix 5

5.1 Absorbed amounts /percents of metal ions during the treatment processes in ion exchange columns using zeolitic tuffs

a. Reddish zeolitic tuff (RZT)

Cation	Effluent velocity					
	400ml/hr			600ml/hr		
	Total (mg/g)	Adsorbed (mg/g)	Absorbed (%)	Total (mg/g)	Adsorbed (mg/g)	Absorbed (%)
Pb^{2+}	10.4	9.2	88	13.6	7.5	55
Cd^{2+}	4.3	0.7	16	4.1	0.4	10
Cu^{2+}	1.7	0.9	54	2.9	0.9	30
Ni^{2+}	3.6	0.2	6	3.7	0.1	3
Zn^{2+}	22.4	3.4	15	19	3	16

b. Brownish zeolitic tuff (BZT)

Cation	Effluent velocity					
	400ml/hr			600ml/hr		
	Total (mg/g)	Adsorbed (mg/g)	Absorbed (%)	Total (mg/g)	Adsorbed (mg/g)	Absorbed (%)
Pb^{2+}	8	7.2	90	13.6	8.2	60
Cd^{2+}	4.1	2.2	54	3.84	1.1	29
Cu^{2+}	0.8	0.6	75	3.2	1.7	53
Ni^{2+}	3.5	1.3	37	3.7	0.8	22
Zn^{2+}	20.8	9.9	48	18.4	6	33