

List of Figures

Figure. 1.1 Primary building unit of SiO ₄ and AlO ₄ . Tetrahedra.	3
Figure 1.2. The main secondary building units (SBUs) of zeolite.	4
Figure (3.1): Distribution of grain size fraction of 100g. brownish or reddish zeolitic tuffs after wet sieving for 15 min. (the average of 10 samples).	26
Figure 3.2: Adsorption apparatus for the elimination of ammonia from the atmosphere.	28
Figure (3.3): Identification of zeolite minerals by scanning electron microscopy.	31
Figure 3.4a and b : Eluted cations (mg/g) from the zeolitic tuff during the regeneration process with salt solutions using the batch system.	33
Figure (3.5): The eluted cations (mg/g) from 20 g. zeolitic tuff (R and B represent Reddish and Brownish zeolitic tuffs respectively).	34
Figure 3.6: Weight loss (%) of zeolitic tuffs related to thermal treatment.	37
Figure 3.7: Water gain (%) of zeolitic tuffs related after the thermal treatment.	37
Figure 3.7.1 Ammonia adsorption on the zeolitic tuffs in their different forms of regeneration.	38
Figure 3.7.2a and b Humidity adsorption by the zeolitic tuffs in a different forms of regeneration.	39
Figure 3.8. Represents the pore opening of different zeolite minerals as well as other cations and H ₂ O and NH ₃ .	40
Figure 4.1 The kinetic of NH ₄ ⁺ released from the previously treated zeolitic tuffs with an ammonium standard solution.	46
Figure 4.2a, b and c Cations adsorbed from the tap water used in relation to ammonium ions extraction from the zeolitic tuffs.	47
Figure 4.3a and b Adsorbed amount of ammonium in relation to the addition amount of zeolitic tuffs and the contact time.	49
Figure 4.4a and b Adsorption-desorption amount (in mg) of counter cations.	50
Figure 4.5a and b The amount of phosphor eliminated from the manure.	52
Figure 4.6a and b Amount of NH ₄ ⁺ ions desorbed from the pretreated zeolitic tuffs with the manure.	
Figure 4.7a and b The dissolution properties of phosphor from pre-treated zeolitic tuffs.	56
Figures 4.8a-d Adsorbed/desorbed cations (mg) from the pretreated tuffs.	57
Figure 5.1 Laboratory scale ion exchange column apparatus.	64

List of Figures

Figure 5.2a and b Worked exchange capacity of Jordanian zeolitic tuff for heavy metal ions.	68
Figure 5.2c Ions uptake from solutions using NaA zeolite and the Jordanian zeolitic tuffs in Na-form.	70
Figure 5.3a Effect of regeneration type on the total adsorption capacity of zeolitic tuffs.	71
Figure 5.3 b Desorbed cations (mg/g) from the different forms of zeolitic tuffs.	72
Figures 5.4 a-e Worked exchange capacities for heavy metals as an effect of the neutralisation type.	73
Figure 5.5 Counter ions effect on the adsorption capacity.	76
Figure 5.6 Amount of Ca^{2+} or Na^+ absorbed on the zeolitic tuffs.	77
Figure 5.7 a-c Desorbed amounts of cations (mg/g) in the equilibrium reaction.	78
Figure 5.8 a. Lead breakthrough curves on Jordanian zeolitic tuffs.	80
Figure 5.8 b. Elution curves of Ca^{2+} and Mg^{2+} from the zeolitic tuffs.	81
Figure 5.8 c. Elution curves of Na^+ and K^+ from the zeolitic tuffs.	81
Figure 5.9a Cd^{2+} breakthrough curves and the outgoing of Na^+ ion.	82
Figure 5.9 b Absorbed amount of Cd^{2+} and desorbed amount of cations from zeolitic tuffs.	83
Figure 5.10 a. Cu^{2+} breakthrough curve on Jordanian zeolitic tuffs.	84
Figure 5.10 b Extracted cations from the treated zeolitic tuffs with Cu^{2+} containing solution.	85
Figure 5.11 a. Breakthrough curves of Ni^{2+} on Zeolitic tuffs.	86
Figure 5.11b. Cations eluted from untreated Jordanian zeolitic tuffs after treated with a solution containing Ni^{2+} .	87
Figure 5.12a. Breakthrough curves of Zn^{2+} on the Jordanian zeolitic tuffs.	88
Figure 5.12b. Eluted sequence of cations from zeolitic tuffs pretreated with Zn^{2+} solutions.	89
Figures 5.13 a-e Breakthrough curves of heavy metal ions on natural form Jordanian zeolitic tuffs.	90
Figures 5.14 Absorbed percent of heavy metals during the processes with different flow rates.	93
Figure 5.15 Total desorbed cations from the zeolitic tuff beds (mg/g).	93
Figures 5.16a and b. Extracted cations during the equilibrium process.	94
Figure 5.17 a and b. Formation of mass transfer zone in the zeolitic tuff beds.	95

List of Figures

Figure 5.18 Percent of heavy metals absorbed in relation to the type of regeneration.	96
Figure 5.19a-c The effect of regeneration-exhaustion processes on the adsorption capacity.	98
Figure 5.20a and b Total absorbed/desorbed amount of heavy metal ions (mg/g).	100
Figure 5.21a and b Microphotographs of cations distribution in Na-form zeolitic tuffs after the 3ed percolation treatment..	101
Figures 5.22 Lead elution curves from the zeolitic tuff beds..	102
Figure 5.23 Elution curves of cadmium from the zeolitic tuff beds..	103
Figure 5.24 Elution curves of copper from the zeolitic tuff beds.	104
Figure 5.25 Elution curves of nickel from the zeolitic tuff beds.	105
Figure 5.26 Elution curves of zinc from the zeolitic tuff beds.	105
Figures 5.27a and b Regeneration efficiencies of exhausted zeolitic tuffs.	106
Figure 5.28a and b. Breakthrough curves of metal ions for both beds of zeolitic tuffs in Na-form.	108
Figure 5.29 .Breakthrough curves of counter ions on zeolitic tuffs in Na-form.	109