

Contents

Preface	ix
1. Introduction	1
1.1 Environment	1
1.2 World Water Distribution	2
1.3 Environmental Pollution	5
1.3.1 Air Pollution	6
1.3.2 Soil or Land Pollution	6
1.3.3 Noise Pollution	7
1.3.4 Water Pollution	7
1.4 Chromium	11
1.4.1 Ecological Effects of Chromium	13
1.5 Nickel	16
1.6 Objectives	20
1.7 Literature Review	20
1.7.1 Water Pollution by Heavy Metals and the Removal of Nickel and Chromium	20
1.8 Adsorption	31
1.8.1 Physical Adsorption	31
1.8.2 Chemical Adsorption	31
1.8.3 Adsorption from Solutions	32
1.8.4 Film Diffusion	34
1.8.5 Pore Diffusion	34
1.9 Adsorption Forces	35
1.10 Adsorption Theories	36
1.10.1 Classification of Adsorption Isotherms	36
2. Material and Methods	39
2.1 Adsorbent Collection and Storage	39
2.2 Adsorbent Modification	39

viii CONTENTS

2.3	Preparation of Adsorbate Cr (VI) and Ni (II) Solution	40
2.4	Instrumentation	40
2.5	Batch Adsorption Experiment	41
2.5.1	Adsorption Experiments	41
2.5.2	Chromium (III) Analysis	42
2.5.3	Analysis of Nickel	43
3.	Results and Discussions	45
3.1	Characterization of Silica Sand	45
3.1.1	Chemical Characterization of Silica Sand	45
3.1.2	Fourier Transform Infrared Spectroscopy	47
3.1.3	SEM Characterization of Silica Sand	47
3.1.4	Determination of pH_{ZPC}	50
3.2	Effect of Contact Time and Initial Concentration of Cr (VI) and Ni (II)	52
3.3	Effect of pH on the Removal of Cr (VI) and Ni (II)	56
3.4	Effect of Temperature on the Removal of Cr (VI) and Ni (II)	60
3.5	Effect of Adsorbent Dosage on the Removal of Cr (VI) and Ni (II)	66
3.6	Adsorption Isotherm	73
3.6.1	Langmuir Isotherm Model	75
3.6.2	Assumptions in Langmuir Isotherm Model	75
3.6.3	Freundlich Isotherm Model	76
3.7	Adsorption Kinetics	79
3.7.1	Pseudo-first-order Kinetic Model	79
3.7.2	Pseudo-second-order Kinetic Model	81
3.7.3	Intraparticle Diffusion Model	84
3.8	Thermodynamic Studies	86
4.	Conclusions	91
	References	94
	Index	103