

**CONTENTS****1. INTRODUCTION**

|                |                                                        |    |
|----------------|--------------------------------------------------------|----|
| 1.1.           | Pollution .....                                        | 1  |
| 1.1.1.         | Type of pollution .....                                | 1  |
| 1.1.1.1.       | Air pollution .....                                    | 1  |
| 1.1.1.2.       | Soil pollution .....                                   | 2  |
| 1.1.1.3.       | Radioactive pollution .....                            | 3  |
| 1.1.1.4.       | Water pollution .....                                  | 4  |
| 1.1.1.4.1.     | Excreta and organic industrial waste .....             | 6  |
| 1.1.1.4.2.     | Infection agents .....                                 | 6  |
| 1.1.1.4.3.     | Plant nutrients .....                                  | 7  |
| 1.1.1.4.4.     | Organic pesticides .....                               | 7  |
| 1.1.1.4.5.     | Waste mineral and chemicals .....                      | 8  |
| 1.1.1.4.6.     | Oil .....                                              | 8  |
| 1.1.1.4.7.     | Radioactive liquid waste .....                         | 8  |
| 1.2.           | Toxicity and Chemistry of Some Heavy Metals .....      | 9  |
| 1.2.1.         | Toxicity of heavy metals .....                         | 9  |
| 1.2.2.         | Chemistry of some heavy metals .....                   | 9  |
| 1.2.2.1.       | Copper .....                                           | 9  |
| 1.2.2.2.       | Zinc .....                                             | 13 |
| 1.2.2.3.       | Cadmium .....                                          | 13 |
| 1.2.2.4.       | Nickel .....                                           | 13 |
| 1.3.           | Different Tools Used for the Management of Waste       |    |
|                | Water .....                                            | 14 |
| 1.3.1.         | Chemical precipitation .....                           | 14 |
| 1.3.2.         | Evaporation .....                                      | 15 |
| 1.3.3.         | Ion exchange .....                                     | 15 |
| 1.3.3.1.       | Type of ion exchange materials .....                   | 16 |
| 1.3.3.1.1.     | Natural ion exchange materials .....                   | 16 |
| 1.3.3.1.1.1.   | Zeolite .....                                          | 16 |
| 1.3.3.1.1.2.   | Nile rose plant (water Hyacinth) .....                 | 17 |
| 1.3.3.1.1.3.   | Animal bone (Animal Tricalcium Phosphate) .....        | 17 |
| 1.3.3.1.2.     | Synthetic ion exchanger materials .....                | 18 |
| 1.3.3.1.2.1.   | Inorganic ion exchanger .....                          | 18 |
| 1.3.3.1.2.1.1. | Properties of synthetic inorganic ion exchanger .....  | 19 |
| 1.3.3.1.2.2.   | Organic resins .....                                   | 20 |
| 1.3.3.1.2.2.1. | Properties of organic resin .....                      | 20 |
| 1.4.           | Treatment of Waste Water Using Inorganic and Organic   |    |
|                | Materials .....                                        | 24 |
| 1.4.1.         | Treatment of waste water using inorganic ion exchanges | 24 |
| 1.4.2.         | Treatment of waste water using organic resins .....    | 30 |

|          | Page                                                                  |
|----------|-----------------------------------------------------------------------|
| 1.4.2.1. | Acrylic acid polymers {P(AA)} ..... 30                                |
| 1.4.2.2. | Acrylamide polymers {P(AM)} ..... 31                                  |
| 1.4.2.3. | Acrylamide polymeric resins and its polymeric<br>impregnated ..... 32 |
| 1.4.3.   | Mechanism of the template polymerization technique .... 33            |
| 1.4.4.   | Factors affecting on the sorption process ..... 34                    |
| 1.4.4.1. | Swelling ..... 34                                                     |
| 1.4.4.2. | Degree of swelling ..... 35                                           |
| 1.4.4.3. | Capacity ..... 35                                                     |
| 1.4.4.4. | Temperature ..... 36                                                  |
| 1.4.4.5. | Particle size and porosity ..... 37                                   |
| 1.4.4.6. | Effect of pH ..... 37                                                 |
| 1.4.4.7. | Selectivity ..... 37                                                  |
| 1.5.     | Literature Survey ..... 39                                            |

## 2. EXPERIMENTAL

|          |                                                                                                    |
|----------|----------------------------------------------------------------------------------------------------|
| 2.1.     | Chemical and Materials ..... 45                                                                    |
| 2.2.     | Equipments ..... 45                                                                                |
| 2.2.1.   | Water thermostat shaker ..... 45                                                                   |
| 2.2.2.   | Infrared spectrophotometer (IR) ..... 45                                                           |
| 2.2.3.   | X-Ray diffraction patterns (XRD) ..... 45                                                          |
| 2.2.4.   | X-Ray fluorescence spectrometer (XRF) ..... 47                                                     |
| 2.2.5.   | Atomic absorption spectrophotometer (AAS) ..... 47                                                 |
| 2.2.6.   | Inductive coupled plasma (ICP) ..... 47                                                            |
| 2.2.7.   | pH-meter ..... 47                                                                                  |
| 2.3.     | Preparation and Characterization of Materials Used ... 47                                          |
| 2.3.1.   | Synthesis of poly(acrylamide-acrylic acid)<br>{P(AM-AA)} resin ..... 47                            |
| 2.3.2.   | Synthesis of poly(acrylamide- acrylic acid) impregnated<br>silicon titanate P(AM-AA)-SiTi ..... 48 |
| 2.3.3.   | Characterization of the prepared samples ..... 48                                                  |
| 2.3.3.1. | Chemical stability ..... 49                                                                        |
| 2.3.3.2. | Determination of swelling degree ..... 49                                                          |
| 2.4.     | Sorption Investigation ..... 49                                                                    |
| 2.4.1.   | Equilibrium time ..... 49                                                                          |
| 2.4.2.   | Effect of sodium hydroxide treatment ..... 50                                                      |
| 2.4.3.   | Apparent capacity measurement ..... 50                                                             |
| 2.4.4.   | Effect of pH of the medium..... 51                                                                 |
| 2.4.5.   | Sorption isotherm ..... 52                                                                         |
| 2.4.6.   | Effect of sodium salt on the sorption behavior of some<br>heavy metals ..... 53                    |
| 2.4.7.   | Column technique ..... 53                                                                          |

### 3. RESULTS AND DISCUSSIONS

|        |                                                                                                                                                                   |     |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 3.1.   | Preparation of Poly(Acrylamide-Acrylic Acid)-Silicon Titanate {P(AM-AA)-SiTi} .....                                                                               | 55  |
| 3.2.   | Characterization of Poly(Acrylamide-Acrylic Acid)-Silicon Titanate {P(AM-AA)-SiTi} .....                                                                          | 57  |
| 3.2.1. | Infrared spectroscopy (IR) .....                                                                                                                                  | 57  |
| 3.2.2. | X-Ray diffraction patterns(XRD) .....                                                                                                                             | 58  |
| 3.2.3. | X-ray fluorescence spectroscopy (XRF) .....                                                                                                                       | 59  |
| 3.2.4. | Chemical stability .....                                                                                                                                          | 59  |
| 3.2.5. | Effect of pH on the dissociation of the resin .....                                                                                                               | 60  |
| 3.3.   | Effect of NaOH Treatment .....                                                                                                                                    | 60  |
| 3.4.   | Batch Investigations.....                                                                                                                                         | 61  |
| 3.4.1. | Effect of contact time on sorption behavior of P(AM-AA)-SiTi .....                                                                                                | 61  |
| 3.4.2. | Effect of batch factor(V/m) .....                                                                                                                                 | 61  |
| 3.4.3. | Effect of pH of the Medium .....                                                                                                                                  | 62  |
| 3.4.4. | Sorption isotherm .....                                                                                                                                           | 63  |
| 3.4.5. | Effect of reaction temperature .....                                                                                                                              | 65  |
| 3.4.6. | Effect of some anionic species on the sorption behavior of $\text{Cu}^{2+}$ , $\text{Cd}^{2+}$ , $\text{Ni}^{2+}$ and $\text{Zn}^{2+}$ ions on P(AM-AA)-SiTi .... | 65  |
| 3.4.7. | Effect of some complexing agent on the sorption behaviour of P(AM-AA)-SiTi .....                                                                                  | 66  |
| 3.4.8. | Apparent capacity measurements .....                                                                                                                              | 67  |
| 3.5.   | Column Studies .....                                                                                                                                              | 68  |
| 3.5.1  | Removal of $\text{Cu}^{2+}$ , $\text{Cd}^{2+}$ , $\text{Ni}^{2+}$ and $\text{Zn}^{2+}$ ions from simulated waste water on P(AM-AA)-SiTi columns .....             | 69  |
| 3.5.2. | Applications on treatment and removal of some toxic heavy metals from waste water using P(AM-AA)-SiTi columns .....                                               | 70  |
|        | SUMMARY .....                                                                                                                                                     | 107 |
|        | REFERENCES .....                                                                                                                                                  | 112 |
|        | ARABIC SUMMARY .....                                                                                                                                              |     |

**LIST OF TABLES**

|            |                                                                                                                                                                                                             |    |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Table (1)  | The occurrence and significance of trace elements in natural wastes and their effects him on human body.....                                                                                                | 10 |
| Table (2)  | General comparison of inorganic with organic ion exchangers .....                                                                                                                                           | 23 |
| Table (3)  | The main chemicals used in this work are listed .....                                                                                                                                                       | 46 |
| Table (4)  | X-ray fluorescence data for poly(Acrylamide-Acrylic Acid)-Silicon Titanate .....                                                                                                                            | 72 |
| Table (5)  | Solubility of P(AM-AA) and P(AM-AA)-SiTi in different media (g/l).....                                                                                                                                      | 73 |
| Table (6)  | Dissociation percentage of silicon titanate from P(AM-AA)-SiTi at different pH values and $25\pm 1^{\circ}\text{C}$ .....                                                                                   | 74 |
| Table (7)  | Degree of affecting of the retention percentage of $\text{Cu}^{2+}$ , $\text{Cd}^{2+}$ , $\text{Ni}^{2+}$ and $\text{Zn}^{2+}$ ions on P(AM-AA)-SiTi with different concentration of some anions.....       | 75 |
| Table (8)  | Degree of affecting of the retention percentage of $\text{Cu}^{2+}$ , $\text{Cd}^{2+}$ , $\text{Ni}^{2+}$ and $\text{Zn}^{2+}$ ions on P(AM-AA)-SiTi with different concentration of complexing agents..... | 76 |
| Table (9)  | Capacity of P(AM-AA)-SiTi for [50ppm] $\text{Cu}^{2+}$ , $\text{Cd}^{2+}$ , $\text{Ni}^{2+}$ and $\text{Zn}^{2+}$ ions at natural pH and $25\pm 1^{\circ}\text{C}$ .....                                    | 77 |
| Table (10) | Concentrations of some toxic heavy metals collected from Kaha Company for Chemical Industries before and after treatment .....                                                                              | 78 |