

CONTENTS

	Page
1. INTRODUCTION	1
2. REVIEW OF LITERATURE	3
2.1. Sources of soil pollution with heavy metals and organic compounds	3
2.1.1. Vehicle exhausts	4
2.1.2. The industrial emissions	4
2.1.3. Irrigation with wastewaters	6
2.1.4. Herbicides	7
2.2. Factors affecting availability of heavy metals	8
2.3. Plant pollution with heavy metals	9
2.4. Bioavailability of heavy metals	11
2.5. Mechanisms of heavy metal uptake by plants	11
2.6. Plant response to heavy metals	14
2.7. Heavy metal detoxification/chelation	15
2.7.1. Organic acids and amino acids	15
2.7.2. The cell wall	15
2.7.3. Plasma membrane	16
2.7.4. Phytochelatins	16
2.7.5. Vacuolar compartmentalization	17
2.8. Bioremediation of contaminated soils	17
2.8.1. Rhizofiltration	18
2.8.2. Phytotransformation (phytodegradation).	19
2.8.3. Phytovolatilization	19
2.8.4. Phytostabilization	20

2.8.5. Phytoextraction	20
2.8.5.1. Long-term continuous phytoextraction	21
2.8.5.2. Induced phytoextraction	21
2.8.5.3. The use of crops for in situ Phytoremediation	22
2.8.6. Enhancing phytoremediative ability of plants	23
2.8.7. Limitaions and advantages of phytoremediation	25
3. MATERIALS AND METHODS	27
3.1. Materials	27
3.1.1. The water samples	27
3.1.2. The soil samples	27
3.1.3. The plant samples	31
3.1.4. The soil amendments used in the experimental work	31
3.2. The experimental work	31
3.2.1. The phytoremediation experiments	31
1. Application of elemental sulfur	32
2. Application of the Nile compost	32
3. Application of EDTA	34

3.2.2 Suitability of maize for phytoremediation.	34
3.2.2.1. Maize growth, arsenic accumulation in shoots and the quality of the grains as influenced by As contamination of soil, irrigation water and ground water	34
3.2.3. Arsenate, arsenite and DMA influxes and toxicity in maize	39
3.2.3.1. Plant material	40
3.2.3.2. Seedling pre-treatment	40
3.2.3.3. Short-term influx	40
3.2.3.4. Tolerance test	41
3.3. Methods of soil analyses	42
3.3.1. Physical analyses	42
3.3.2. Chemical analyses	42
3.4. Plant analyses	43
3.5. Water analyses	44
3.6. Analytical quality control	44
3.7. Data analysis	44
4. RESULTS AND DISCUSSION	46
4.1. Evaluation of the investigated waters for heavy metals toxicities	46
4.2. Heavy metal concentrations in the investigated soils	49
4.3. Heavy metal phytoextraction by maize	53

4.4. Phytoremediation of the heavy metals contaminated soils using geranium plants	62
4.4.1. Effects of the different applied amendments on dry matter yield	62
4.4.2. Effect of the different applied amendments on the concentrations of heavy metals in plant organs	72
4.4.2.1. The enhancing effect of the applied elemental sulfur	75
4.4.2.2. The enhancing effect of the applied Nile compost	76
4.4.2.3 The enhancing effect of the applied EDTA	77
4.4.3. Effect of the different applied amendments on translocation of heavy metals within plant organs	78
4.5. Evaluation of using maize in phytoremediation of As-contaminated soil	82
4.5.1 Maize growth, Asumulation in shoots and grains as influenced by contamination of soil and pro-longed sub-irriagtion used ionized water in As contaminated water	83
4.5.1.1. Effect of soil contamination with As on its accumulation in shoots and grains during the different growth stages	83

4.5.1.2. Accumulation of arsenate in shoots during the reproductive stages of maize	87
4.5.1.3. Effect of prolonged sub-irrigation on As accumulations in shoots and grains	90
4.5.1.4. Comparing As concentrations in shoots and grains of different varieties as affected by As contamination in soil	94
4.5.2. Arsenate/arsenite/DMA uptake	
4.5.2.1. Arsenate uptake	94
4.5.2.2. Arsenite uptake	100
4.5.2.3. DMA uptake	104
4.5.3. Arsenate, arsenite and DMA toxicity in maize	109
5. SUMMARY	113
6. REFERENCES	120
ARABIC SUMMARY	