

# **AMELIORATION OF DEGRADED SOILS IRRIGATED WITH LOW QUALITY WATER**

**By**

**HESHAM MANSOUR EID**

**B.Sc. Agric. Sci. (Soils and Water), Fac. Agric., Fayoum Univ., 2011**

**THESIS**

**Submitted in Partial Fulfillment of the  
Requirements for the Degree of**

**MASTER OF SCIENCE**

**In**

**Agricultural Sciences  
(Soil Science)**

**Department of Soil  
Faculty of Agriculture  
Cairo University  
EGYPT**

**2018**

## **APPROVAL SHEET**

# **AMELIORATION OF DEGRADED SOILS IRRIGATED WITH LOW QUALITY WATER**

**M.Sc. Thesis  
In  
Agric. Sci.(Soil Science)**

**By**

**HESHAM MANSOUR EID**

**B.Sc. Agric. Sci. (Soils and Water), Fac. Agric., Fayoum Univ., 2011.**

## **APPROVAL COMMITTEE**

**Prof. Dr. EHAB ABDEL HALIM ELSYAD.....**  
**Professor of Soil, Fac. Agric., Fayoum University**

**Prof. Dr. MAHER ABDEL MOHSEN ABDEL HAMID.....**  
**Professor of Soil, Fac. Agric., Cairo University**

**Prof. Dr. EL SAID AHMED EL MORSY.....**  
**Professor of Soil, Fac. Agric., Cairo University**

**Prof. Dr. MOHAMEDY IBRAHEM EL KHERBAWY.....**  
**Professor of Soil, Fac. Agric., Cairo University**

**Date:    /    / 2018**

**SUPERVISION SHEET**

**AMELIORATION OF DEGRADED SOILS  
IRRIGATED WITH LOW QUALITY WATER**

**M.Sc. Thesis  
In Agric. Sci. (Soil Science)**

**By**

**HESHAM MANSOUR EID**

**B.Sc. Agric. Sci. (Soils and Water), Fac. Agric., Fayuom Univ., 2011.**

**SUPERVISION COMMITTEE**

**Dr. MOHAMEDY IBRAHEM EL KHERBAWY**  
**Professor of Soil, Fac. Agric., Cairo University.**

**Dr. EL SAID AHMED EL MORSY**  
**Professor of Soil, Fac. Agric., Cairo University.**

**Dr. ALAA EL DEN MOHAMMED ZAGHLOUL**  
**Professor of Soil, Soils and Water Use Dept., NRC, Giza.**

**Name of Candidate:** Hesham Mansour Eid

**Degree:** MS.c.

**Title of Thesis:** Amelioration of degraded soils irrigated with low quality water

**Supervisors:** Dr. Mohamedy Ibrahim El-Kherbawy

Dr. El said Ahmed El morsy

Dr. Alaa El den Mohammed Zaghloul

**Department:** Soils

**Branch:** Soil Science

**Approval:** 4/2/2018

### ABSTRACT

The current research work studied the impact of low quality waters varied in their sources of contamination on soil characteristics and vegetables grown in these soils as well as possible biochemical remediation of such soils. Results implied that application of low quality water led to increase Zn equivalent parameter as an index of increasing heavy metals in the studied soils. The concentration of contaminants in Kafr-Elsheikh soil was the highest, followed by Kombora and Abo Rawash which revealed that, total and available forms of varied contaminants were higher existed in the heavy texture soils than in the light ones. In the greenhouse remediation study on Kafr-Elsheikh contaminated soil, five treatments were applied including chemical remediative ammendments *i.e.*, elemental sulfur, rock phosphate, probentonite, prokaolinite and compost extract, and biological remediatve ammendments (*Thiobacillus thiooxidans*, *Thiobacillus ferrooxidans*, phosphate dissolving bacteria, *Pseudomonas fluorescens* and arbuscular mycorrhizae) and growing hyper accumulator plants *i.e.*, Radish and Turnip in both individual and mixture applications and irrigated with the same contaminated water used in the field. Results implied that application of integrated management with radish plant as hyper accumulator plant was the best for minimizing the hazards of contaminated irrigation water. The three treatments which gave the most significant improvement *i.e.*, elemental sulfur, rock phosphate and inoculated with a mixture of *Thiobacillus thiooxidans*, *Thiobacillus ferrooxidans*, phosphate dissolving bacteria, arbuscular mycorrhizae (AM) and enriched with compost extract (T<sub>3</sub>), combined mixture of probentonite and prokaolinite and inoculated with *Pseudomonas fluorescens*, arbuscular mycorrhizae (AM) and enriched with extracted compost (T<sub>4</sub>), and combined mixture of all the remediative ammendments (T<sub>5</sub>) were selected to be evaluated under field conditions with radish hyper accumulator plant. Results showed that the same trend obtained in greenhouse with significant improvement in soil characteristics. In addition, these treatments especially the integrated management significantly decreased the concentration of heavy metals in radish plant. In conclusion, minimizing the hazards of heavy metals by natural modified local products could be the best management practices in having healthy food.

**Key words:** Management practices, heavy metals, soil contamination, low quality water.

## **DEDICATION**

*This thesis would never have been completed without the compassion and support of my beloved father, mother, sisters and wife. My words would not be enough to thank all of you. I dedicate this work to all of you.*

## *ACKNOWLEDGMENT*

*First and foremost, all the praises and limitless thanks are to **ALLAH** who gave me the capability to do this work.*

*I wish to express my gratitude and appreciation to my supervisors **Dr. M. El-kherbawy** and **Dr. E. Elmorsy**, Professors of Soil, Faculty of Agriculture, Cairo University, and **Dr. A. Zaghloul** Professor of Soil, NRC, Egypt, who gave me an opportunity to work under their supervision and helpful guidance.*

*Special thanks to **Dr. E. Elsyad**, Professor of soil Science, Soil and Water Department, Fayoum University, who gave me an opportunity to study basics of soil chemistry under his supervision, also for revision and judging this work.*

*Special thanks to **Dr. M. Abdel Mohsen**, Professor of soil, Faculty of Agriculture, Cairo University, for constructive criticism, revision and judging this work.*

*I would like to show my whole hearted and best thanks to **Prof. Dr. F. Awad** and **Prof. Dr. M. Saber**, NRC, Egypt, for supervision, valuable suggestion to better my work and finally the technical advice. I am proud and honored to be your student.*

*The author is indebted to **Prof. Dr. S. El Ashry**, NRC, Egypt, for her faithful support and helping to achieve numerous tasks in this work. I acknowledge the kindness of the research group of soil chemistry Lab, Soils and Water Use Dept, NRC, Egypt, for their encouragement and for a friendly face. I am very thankful to all members of the Department.*

# CONTENTS

	Page
<b>INTRODUCTION.....</b>	<b>1</b>
<b>REVIEW OF LITERATURE.....</b>	<b>3</b>
<b>1. Water Scarcity and Reuse of Low Quality Water.....</b>	<b>3</b>
<b>2. Sources and Risks of Heavy Metals on Soil Ecosystem</b>	<b>4</b>
<b>a. Sources of water contaminants.....</b>	<b>4</b>
<b>b. Categories of low quality water (LQW) contaminants.....</b>	<b>4</b>
<b>c. Risks of heavy metals on soil ecosystem.....</b>	<b>5</b>
<b>d. Risks of heavy metals on plant growth.....</b>	<b>6</b>
<b>3. Adverse Impacts of Irrigation with LQW.....</b>	<b>7</b>
<b>4. Chemistry of Heavy Metals in Soil Ecosystem.....</b>	<b>7</b>
<b>a. Effect of contaminants in LQW on soil ecosystem..</b>	<b>10</b>
(1) Zinc.....	10
(2) Copper.....	10
(3) Nickel.....	10
(4) Cadmium.....	11
(5) Arsenic.....	11
<b>b. Kinetic studies on contaminants in soils.....</b>	<b>13</b>
<b>c. Factors affecting mobility and adsorption of heavy metals in soil ecosystems.....</b>	<b>14</b>
<b>d. Bioavailability and bioaccumulation of heavy metals in soil ecosystem.....</b>	<b>15</b>
<b>e. Impact of heavy metals on edible parts of vegetables.....</b>	<b>17</b>
<b>5. Biological and Chemical Remediation Technologies....</b>	<b>18</b>
<b>a. Plant-based technology to clean up heavy metals from contaminated soils.....</b>	<b>19</b>
<b>b. Chemical remediation techniques.....</b>	<b>22</b>
(1) Use of rock phosphate.....	23
(2) Use of clay minerals.....	24
(3) Use of elemental sulfur.....	25

c. Microorganisms efficiency in bioremediation of contaminated soil ecosystems.....	25
d. Role of Arbuscular mycorrhiza (AM) in contaminated soils.....	27
<b>MATERIALS AND METHODS.....</b>	<b>29</b>
<b>1. Materials.....</b>	<b>29</b>
a. Water sampling.....	29
b. Soil sampling.....	29
(1) Sampling of soils irrigated with sewage effluents.....	30
(2) Sampling of soils irrigated with a mixture of industrial effluents, agricultural drainage and Nile water.....	30
<b>2. Methods of soil analysis.....</b>	<b>30</b>
a. Chemical characterization.....	30
b. Physical analysis.....	33
c. Microbiological analysis.....	34
d. Statistical analysis.....	34
<b>3. Greenhouse experiments.....</b>	<b>34</b>
a. Materials.....	34
(1) Clay minerals loaded with microbes.....	34
(2) Chemical ammendments.....	35
(3) Microorganisms.....	35
b. Experimental Design.....	36
<b>4. Field experiments.....</b>	<b>38</b>
<b>RESULTS AND DISCUSSION.....</b>	<b>41</b>
<b>1. Chemical characterization of the studied low quality water (LQW).....</b>	<b>41</b>
a. Water salinity and pH.....	41
b. Heavy metals content in the studied water.....	43
<b>2. Physical and chemical characteristics of the studied soils.....</b>	<b>45</b>
<b>3. Kinetics desorption of some heavy metals.....</b>	<b>50</b>
<b>4. Evaluation of biochemical remediation of contaminated soil.....</b>	<b>53</b>



<b>a. Greenhouse experiments.....</b>	<b>53</b>
(1) Effect of remediation treatments on total concentration of heavy metals in contaminated soil.....	53
(2) Kinetics of some heavy metals release from the contaminated soil as affected by biochemical remediation treatments.....	58
(3) Effect of biochemical remediation treatments on Zn equivalent parameter.....	69
(4) Radish and Turnip as indicator plants for heavy metals phytoremediation for contaminated soil....	72
<b>b. Field evaluation of biochemical remediation of contaminated soils irrigated with low quality water.....</b>	<b>78</b>
(1) Effect of remediation treatments on heavy metals concentration.....	78
(2) Kinetics of some heavy metals release from the soil as affected by the followed integrated chemo-biotechnology.....	83
(3) Effect of remediation treatments on Zn equivalent parameter.....	89
(4) Radish plant as an indicator for heavy metals remediation from contaminated soil.....	90
(5) The relation between heavy metals, Zn equivalent and Dehydrogenase activity.....	92
(6) Effect of various treatments on soil salinity and soluble anions.....	96
(7) Effect of various treatments on radish plant growth.....	101
<b>CONCLUSIONS.....</b>	<b>105</b>
<b>SUMMARY.....</b>	<b>107</b>
<b>REFERENCES.....</b>	<b>115</b>
<b>ARABIC SUMMARY.....</b>	

## LIST OF TABLES

No	Title	Page
1.	Chemical characteristics of the studied water samples.....	42
2.	Total concentration of heavy metals in the studied irrigation waters.....	43
3.	Soluble concentrations of some heavy metals in the studied irrigation waters.....	44
4.	Particle size distribution (%) of the studied soils.....	45
5.	Electrical conductivity (EC <sub>e</sub> ), soluble cations and anions of the studied soils.....	46
6.	Organic matter, nitrogen, phosphorus and potassium content the studied soil samples.....	47
7.	Available concentrations of heavy metals in the studied soils.....	48
8.	Total concentrations of heavy metals in the studied soils	49
9.	Effect of remediation treatments on total concentration of some heavy metals in the studied soil (ppm).....	55
10.	Kinetic parameters, R <sup>2</sup> and SE of kinetic models used in describing some heavy metals release from studied soil cultivated with hyper accumulator plants as affected by various treatments.....	63
11.	Kinetic parameters, intensity factor <i>a</i> and capacity factor <i>b</i> for different models used in describing some heavy metals release from the studied soil cultivated with hyper accumulator plants as affected by various treatments.....	65
12.	Heavy metals concentrations in <u>radish</u> plant grown in contaminated soil as affected by various treatments.....	73
13.	Heavy metals concentrations in <u>turnip</u> plant grown in a contaminated soil as affected by various treatments.....	74
14.	Effect of remediation treatments on total concentration of the tested heavy metals in the studied soil.....	79
15.	Effect of remediation treatments on kinetic parameters of some heavy metals release from the studied soil.....	85

16.	Heavy metals concentration in radish plant grown in contaminated soil as affected by various treatments (ppm).....	91
17.	Dehydrogenase activity DHA in contaminated soil as affected by various treatments.....	94
18.	Soluble salts ( $EC_e$ ), soluble cations and SAR in studied soils as influenced by various treatments.....	98
19.	Effect of various treatments on plant parameters in Kafr-Elsheikh contaminated soil.....	103

## LIST OF FIGURES

No	Title	Page
1.	Location of studied soil samples in the different Governorates.....	29
2.	Zn equivalent values in studied surface and subsurface soil samples compared to critical level.....	50
3.	Kinetic of Zn, Cu and Ni desorption from the studied soil samples.....	52
4.	Effect of various treatments on decrease percentage of heavy metals in Kafr-Elsheikh contaminated soil.....	56
5.	Effect of various treatments on decrease percentage of heavy metals in Kafr-Elsheikh contaminated soil.....	57
6.	Kinetic of Zn, Cu and Ni desorption from the studied soil samples.....	60
7.	Modified freundlich model describing Zn, Cu and Ni desorption.....	61
8.	Elovich model describing Zn, Cu and Ni desorption.....	62
9.	Zn equivalent values in biochemical remediated soil cultivated with hyper accumulator plants in the greenhouse.....	71
10.	Concentration of some heavy metals accumulated in shoots of radish and turnip plants as affected by various treatments.....	76
11.	Concentration of some heavy metals accumulated in roots of radish and turnip plants as affected by various treatments.....	77
12.	Effect of various treatments on total concentrations of some heavy metals in Kafr-Elsheikh soil cultivated with radish plant.....	81
13.	Effect of various treatments on decrease percentage of some heavy metals in Kafr-Elsheikh soil cultivated with radish plant.....	82
14.	Kinetic of Zn, Cu and Ni desorption from the studied soil samples.....	86
15.	Modified freundlich model describing Zn, Cu and Ni desorption.....	87
16.	Elovich model describing Zn, Cu and Ni desorption.....	88

17. Effect of trailed remediation amendments on Zn equivalent parameter.....	90
18. Concentration of some heavy metals in radish plant as affected by various treatments.....	93
19. Relation between total heavy metals and dehydrogenase activity in contaminated soil as affected by various treatments.....	95
20. Relation between Zn equivalent and dehydrogenase activity in contaminated soil as affected by various treatments.....	96
21. Effect of various treatments on soil salinity (EC <sub>e</sub> ).....	97
22. Effect of various treatments on concentrations of soluble cations.....	99
23. Effect of various treatments to radish cultivated soil on soil SAR.....	100
24. Effect of various treatments on plant parameters of radish cultivated in Kafr-Elsheikh contaminated soil....	104



# INTRODUCTION

No doubt water is a vital resource for farming and human existence as well. The current shortage in fresh water resources coupled with the escalating demands provoked many countries in arid and semi-arid regions to use low quality water in farming. Certainly, low quality water drastically deteriorates soil ecosystem. In association with the recently observed increases in population and rises in economic and social activities in Egypt, the anxiety on water scarce is elevating. In other words, Egyptian farmers would receive in the very near future less irrigation water both in quantity and quality. For that, decision-makers have adapted numerous plans to trustworthy water resources. It is imperious to save and conserve water while providing necessary plans to satisfy the social and economic needs in a sustainable policy.

It is worthy to state that the water sources in Egypt are apt to countless types of contaminants, both chemical and biological, arising from varied sources. Such situations adversely impacted the quality of irrigation water, as well as the appropriateness of crop harvest for human and animal consumption.

One of the core of the current Egyptian water policy is the reuse of low quality water, mainly agriculture drainage water and treated sewage effluent, including a periodically monitoring of their adverse agro-environmental consequences. The low quality water is always polluted with enteric pathogens, organic toxins as well as certain heavy metals posing environmental hazard to both human and biodiversity, besides restricting water reuse. Certainly monitoring these hazards