

**PHYTOREMEDIATION POTENTIAL OF  
*BRASSICA JUNCEA* L. FOR HEAVY METALS  
POLLUTED SOIL IN EL – GABAL EL – ASFAR  
REGION.**

By  
**ALI SAID MOHAMED HASSEN ABO AL – NAGAA**  
B. Sc. Agric. Sc. (Horticulture), Ain Shams University, 2006.

**A thesis submitted in partial fulfillment  
of  
the requirements for the degree of**

**MASTER OF SCIENCE**

**in  
Agricultural Science  
(Plant Physiology)**

**Department of Agricultural Botany  
Faculty of Agricultural  
Ain Shams University**

**2012**

**PHYTOREMEDIATION POTENTIAL OF  
*BRASSICA JUNCEA* L. FOR HEAVY METALS  
POLLUTED SOIL IN EL – GABAL EL – ASFAR  
REGION.**

By

**ALI SAID MOHAMED HASSEN ABO AL – NAGAA**

B. Sc. Agric. SC. (Horticulture), Ain Shams University, 2006.

**Under the supervision of:**

**Dr. Moustafa Ali Amer**

Prof. Emeritus of Plant Physiology, Agricultural Botany Department,  
Faculty of Agriculture, Ain Shams University. (Principal Supervisor)

## ACKNOWLEDGEMENT

**First and foremost, I feel always indebted to Allah, the most  
beneficent and merciful**

The author wishes to express his gratitude and indebtedness to **Dr. Moustafa Ali Amer, Professor of Plant Physiology, Agric. Bot. Dept., Faculty of Agric., Ain Shams Univ.**, main supervisor, who initially suggested the problem specially during the experimental course of study and during the preparation of this thesis and continuous encouragement, words are not enough to express how grateful, I am to him.

I wish to extend my appreciation and gratitude to **Dr. Sayed Hussin, Lecturer of Plant Physiology, Agric. Bot. Dept., Faculty of Agric., Ain Shams Univ.** for his constant guidance and helping me to fully achieve this work and thank him for this effort to get out of this work in this way.

Thanks and appreciation to **Dr. Hatem Ashour, Lecturer of Plant Physiology, Agric. Bot. Dept., Faculty of Agric., Ain Shams Univ.** to provide a helping hand and help me.

I express my thanks and gratitude to **Dr. Ahmed Abdel-Wahab, Associate Professor of microbiology, Agric. Micro. Dept., Faculty of Agric., Ain Shams Univ.** to help me fully achieve this work.

Tribute to **Dr. Taha Abdel-Fattah Khudair, Associate Professor of microbiology, Agric. Micro. Dept., Faculty of Agric., Ain Shams Univ.** for helping me in the scientific and applied wastewater treatment used in the experiment and I call on him for mercy and forgiveness.

Thanks are also extended to all members of Agric. Botany Dept. for their kindness and help that made such work possible.

The supervisor add his own feelings towards **Dr. Sayed Hussin** for his sincere effort offered during preparing the final steps needed for this work and **Dr. Hatem Ashour** for his assistance.

## ABSTRACT

**Ali Said Mohamed Abo Al –Nagaa: Phytoremediation Potential of *Brassica Juncea* L. for Heavy Metals Polluted Soil in El–Gabal El–Asfar Region. Unpublished M.Sc. Thesis, Department of Agricultural Botany, Faculty of Agriculture, University of Ain Shams, 2012.**

The results of this study revealed that spraying Indian mustard plants with humic acid irrigated with treated water in presence of magnetic iron achieved an increase in root length, plant height and number of leaves to be significantly higher than EDTA treatment without magnetic iron. It also activated dry matter production for root and shoot. Furthermore, such behavior reflected itself on yield production not only above EDTA without magnetic iron, but also in the presence of magnetic iron to be significantly higher in terms of number of pods, their weights and weight of 100 seeds. At the same time, increased oil percentage to surpass that attained by EDTA treatment without magnetic iron Although less than that of EDTA treated with MI yet, higher than that attained with humic in presence of magnetic iron.

The repetition of cultivation with the same treatment in presence of magnetic iron induced high total amounts of N, P and K for shoot against the 1<sup>st</sup> season. Also, it increased shoot and root micronutrients. Whereas, it differed for heavy metals and Na. These results are in accordance with the soil analysis of these treatments. Since N, P and K as well micronutrients in presence of magnetic iron decreased with the repetition of cultivation of Indian mustard plants, meanwhile heavy metals and Na still higher in the soil. So, it may be discussed on the role of magnetic iron in preventing the uptake of heavy metals as well Na by mustard plants. Thus, it is obvious the beneficial effect of magnetic iron in preventing the deleterious effect of heavy metals and Na to induce healthy seeds.

**Keywords:** *Brassica juncea*, Phytoremediation, Heavy metals, EDTA, Sulfur, Humic acid, citric acid, Spermidine and Magnetic iron.

## CONTENTS

No.		Page
	<b>LIST OF TABLES .....</b>	<b>IV</b>
	<b>LIST OF FIGURES.....</b>	<b>IX</b>
<b>1</b>	<b>INTRODUCTION .....</b>	<b>1</b>
<b>2</b>	<b>REVIEW OF LITERATURE .....</b>	<b>4</b>
2.1	Ethylene diamine tetra acetic acid (EDTA) .....	4
2.2	Sulfur .....	9
2.3	Humic acid .....	11
2.4	Spermidine .....	12
2.5	Citric acid .....	13
2.6	Magnetic iron .....	16
2.7	Use of microorganisms for heavy metals biosorption .....	18
<b>3</b>	<b>MATERIALS AND METHODS .....</b>	<b>23</b>
3.1	First experiment .....	23
3.2	Second experiment .....	28
3.3	Chemical determinations of Indian mustard plant	32
3.3.1	Total nitrogen .....	32
3.3.2	Total Phosphorus .....	33
3.3.3	Total potassium .....	33
3.3.4	Micronutrients, Heavy metals and sodium .....	33
3.3.5	Determination of oil in Indian mustard seeds .....	33
3.4	Soil determinations .....	33
<b>4</b>	<b>RESULTS .....</b>	<b>35</b>
4.1	First experiment .....	35
4.1.1	Growth characters.....	35
4.1.1.1	Root length .....	35
4.1.1.2	Plant height .....	35
4.1.1.3	Number of leaves .....	35

## II

4.1.2	Fresh and Dry weights .....	37
4.1.2.1	Root .....	37
4.1.2.2	Shoot .....	37
4.1.3	Yield (weight of pods and 100 seeds) .....	39
4.1.4	Oil percentage .....	40
4.1.5	Chemical constituents .....	40
4.1.5.1	Root .....	40
4.1.5.1.1	Macronutrients (N, P and K) .....	40
4.1.5.1.2	Micronutrients (Fe, Cu, Mn and Zn), Heavy metals (Pb and Cd) and Na.....	44
4.1.5.2	Shoot system .....	48
4.1.5.2.1	Macronutrients .....	48
4.1.5.2.1	Micronutrients (Fe, Cu, Mn and Zn), Heavy metals (Pb and Cd) and Na.....	48
4.1.5.3	Seeds .....	54
4.1.5.3.1	Macronutrients .....	54
4.1.5.3.2	Micronutrients (Fe, Cu, Mn and Zn), heavy metals (Pb and Cd) and Na.....	54
4.2	Second experiment .....	54
4.2.1	Growth characters .....	57
4.2.1.1	Root length:.....	57
4.2.1.2	Plant height .....	57
4.2.1.3	Number of leaves .....	58
4.2.2	Fresh and dry weights .....	61
4.2.2.1	Root .....	61
4.2.2.2	Shoot .....	63
4.2.3	Yield (number of pods, weight of pods and weight of 100 seeds).....	65
4.2.4	Oil percentage:.....	66
4.2.5	Chemical constituents .....	66
4.2.5.1	Root system .....	66
4.2.5.1.1	Macronutrients (N, P and K) .....	66

### III

4.2.5.1.2	Micronutrients (Fe, Cu, Mn and Zn), Heavy metals (Pb and Cd) and Na.....	74
4.2.5.2	Shoot system .....	85
4.2.5.2.1	Macronutrients (N, P and K) .....	85
4.2.5.2.2	Micronutrients (Fe, Cu, Mn and Zn), Heavy metals (Pb and Cd) and Na.....	87
4.2.5.3	Seeds .....	91
4.2.5.3.1	Macronutrients (N, P and K) .....	91
4.2.5.3.2	Micronutrients (Fe, Cu, Mn and Zn), Heavy metals (Pb and Cd) and Na.....	91
4.2.6	Changes in soil content after cultivation with Indian mustard during two seasons .....	95
<b>5</b>	<b>DISCUSSION .....</b>	<b>105</b>
5.1	First experiment .....	105
5.2	Second experiment .....	109
<b>6</b>	<b>SUMMARY .....</b>	<b>113</b>
<b>7</b>	<b>REFERENCES .....</b>	<b>119</b>
<b>8</b>	<b>APPENDIX</b>	
<b>9</b>	<b>ARABIC SUMMARY</b>	

## LIST OF TABLES

No.		Pages
1	Physical properties of El Gabal El Asfar Soil (First experiment).....	24
2	Chemical properties of El Gabal El Asfar Soil (First experiment).....	24
3	Chemical properties of untreated water of El Gabal EL Asfar (first experiment). ....	25
4	Chemical properties of treated water of El Gabal El Asfar (first experiment ) ....	26
5	Physical properties of El Gabal El Asfar Soil. (Second experiment). ....	29
6	Chemical properties of El Gabal El Asfar Soil (Second experiment).....	29
7	Chemical properties of untreated water of El Gabal El Asfar (Second experiment).....	30
8	Chemical properties of treated water of El Gabal El Asfar water (second experiment) ....	31
9	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on root length, plant height and number of leaves per plant of Indian mustard plant during 2007 season.....	36
10	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on fresh and dry weights of the root and shoot of Indian mustard plant during 2007 season .....	38
11	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on weight of pods/plant, weight of 100 seeds and oil percentage of	



	the seeds of Indian mustard plants during 2007 season.....	41
12	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on nitrogen (N), phosphorus (P) and potassium (K) percentages in the root of Indian mustard plants during 2007 season.....	42
13	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), lead (Pb), cadmium (Cd) concentrations and sodium (Na) percentage in the root of Indian mustard plants during 2007 season.....	45
14	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on nitrogen (N), phosphorus (P) and potassium (K) percentages in the shoot of Indian mustard plants during 2007 season.....	49
15	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), lead (Pb), cadmium (Cd) concentrations and sodium (Na) percentage in the shoot of Indian mustard plants during 2007 season. ....	51
16	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on nitrogen (N), phosphorus (P) and potassium (K) percentages in	

	the seeds of Indian mustard plants during 2007 season.....	55
17	Effect of soil applications (EDTA, sulfur and humic acid), foliar applications (spermidine, citric acid and humic acid) and magnetic iron application on iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), lead (Pb), cadmium (Cd) concentration (PPM) and sodium (Na) percentage in the seeds of Indian mustard plants during 2007 season.. .....	56
18	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on root length, plant height and number of leaves of Indian mustard plants (second experiment).....	59
19	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on fresh and dry weights of the root of Indian mustard plants (second experiment).....	62
20	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on fresh and dry weights of the shoot of Indian mustard plants (Second experiment) .....	64
21	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on the number of pods , weight of pods per plant and weight of 100 seeds of the Indian mustard (Second experiment).....	67
22	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on nitrogen (N), phosphorus (P) and potassium (K) percentages in the root of Indian mustard (Second experiment ). .....	69

## VII

23	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) concentration (PPM) in the root of Indian mustard (Second experiment ).....	75
24	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on lead (Pb) and cadmium (Cd) concentrations (ppm) in the root of Indian mustard plants (second experiment). ....	80
25	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on sodium (Na) percentages in root Indian mustard plants (second experiment). ....	83
26	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on nitrogen (N), phosphorus (P) and potassium (K) percentages in the shoot of Indian mustard plants (second experiment).....	86
27	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) concentrations (ppm) in the shoot of Indian mustard plants (second experiment). ....	89
28	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on lead (Pb) and cadmium (Cd) concentrations (ppm) in the shoot of Indian mustard plants (second experiment).....	90
29	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on sodium (Na) percentage in the shoot	

## VIII

	of Indian mustard plants (second experiment).....	92
30	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on nitrogen (N), phosphorus (P) and potassium (K) percentages in the seeds of Indian mustard plants (second experiment).....	93
31	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) concentrations (ppm) in the seeds of Indian mustard plants (Second experiment).....	94
32	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on lead (Pb) and cadmium (Cd) concentrations (ppm) in the seeds of Indian mustard plants (second experiment).....	96
33	Effect of soil applications (EDTA, sulfur and humic acid), combined with foliar humic application and magnetic iron on sodium (Na) percentage in the seeds of Indian mustard plants (second experiment). ....	97
34	Relative changes in soil content after the cultivation of Indian mustard plant treated with different applications during two seasons.....	98
35	The elevation percentage of soil N, P and K at the end of the 1 <sup>st</sup> season (2008) relative to the 2 <sup>nd</sup> one (2009).....	102
36	The elevation percentage of soil Fe, Cu, Mn and Zn at the end of the 1 <sup>st</sup> season (2008) relative to the 2 <sup>nd</sup> one (2009).....	103
37	The elevation percentage of soil Pb, Cd and Na at the end of the 1 <sup>st</sup> season (2008) relative to the 2 <sup>nd</sup> one (2009).....	104

# LIST OF FIGURES

NO.		Pages
1	Total macronutrient (N, P and K) amount in the roots of Indian mustard plants 50 days after sowing with or without magnetic iron during the 1 <sup>st</sup> experiment.....	43
2	Total micronutrient (Fe, Cu, Mn and Zn) amount in the roots of Indian mustard plants 50 days after sowing with or without magnetic iron during the 1 <sup>st</sup> experiment .....	46
3	Total amount of Pb, Cd and Na in the roots of Indian mustard plants 50 days after sowing with or without magnetic iron during the 1 <sup>st</sup> experiment.....	47
4	Total macronutrient (N, P and K) amounts in the shoot of Indian mustard plants 50 days after sowing with or without magnetic iron during the 1 <sup>st</sup> experiment .....	50
5	Total micronutrient (Fe, Cu, Mn and Zn) amounts in the shoot of Indian mustard plants 50 days after sowing with or without magnetic iron during the 1 <sup>st</sup> experiment .....	52
6	Total amounts of Pb, Cd and Na in the shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the 1 <sup>st</sup> experiment.....	53
7	Total N amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	71
8	Total P amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	72
9	Total K amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right)	

	seasons of the 2 <sup>nd</sup> experiment .....	73
10	Total Fe amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	76
11	Total Cu amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	77
12	Total Mn amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	78
13	Total Zn amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	79
14	Total Pb amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	81
15	Total Cd amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	82
16	Total Na amounts in the roots and shoots of Indian mustard plants 50 days after sowing with or without magnetic iron during the first (left) and second (right) seasons of the 2 <sup>nd</sup> experiment .....	84

## INTRODUCTION

Water scarcity is projected to become an important determinant for agricultural production and food security worldwide, particularly in arid and semi-arid regions, where one-sixth of the world population lives (World Bank, 1999; UNDP, 2007). The upcoming challenge of global climate changes are further adding to the deteriorating situation of water shortage (FAO and IFAD, 2006; Geissler *et al.*, 2010). As a consequence of increasing competition over limited water resources, agriculture (dominant user, accounting for about 80% of global water use) is inevitably forced to utilize marginal or sewage water (treated or even untreated) to meet the increasing demands.

Although disposal of wastewater to crop irrigation is as ancient as humankind's cultivation of land, large-scale controlled waste water utilization for irrigation dates only back to last century when so-called sewage farms were established for the purpose of disposing of waste water to prevent river pollution. Estimates on wastewater utilization indicate that about 20 million hectares of agricultural land is irrigated with (treated and untreated) wastewater in around 50 countries worldwide (Bartone and Arlosoroff, 1987). When used properly, this approach is reliable and cost effective with substantial benefits for soil and water resources management as well as plant growth and yields due to its nutrient contents (Sadek and Sawy, 1989; Peterson *et al.*, 1994; Pradhan *et al.*, 2001; Abd-Elfattah *et al.*, 2002). However, it can lead to the accumulation of phytotoxic levels of heavy metals in soils and plant tissues, especially when untreated water is used for crop irrigation (Lutric *et al.*, 1982; Eid, 1984; McBride *et al.*, 1999; Bansal, 2004; Kafeel *et al.*, 2011). Therefore, this poses a great potential threat to the environment and human health.

In Egypt, the use of sewage effluent for irrigation has been practiced more than 100 years ago. The first tree plantation, originally of 200 ha, utilizing treated sewage water in El-Gabal El-Asfar farm (about 30 km from Cairo) was established in 1911 to dispose of the city