

**Tarek Mohamed Yhaya Omar**  
Central. Lab. for Food and Feed,  
Agriculture Research Center

**Evaluating the Reuse of Sewage in Egypt: Environmental  
Disciplines, Pollutants and Treatment**

**ABSTRACT**

The aim of the present investigation is to evaluate the reuse of sewage in Egypt from the point of environmental discipline, pollution and treatment. The work given in this thesis deals with two essential parts, the first part includes the reuse of sewage water for irrigation the sandy soil present at El-Gabal El-Asfar, Abu-Rawash and Alexandria.

The second part includes the treatment processes of wastewater and treated sewage water by using different materials to remove heavy metals.

Many soil profiles were taken to represent soils irrigated for different periods (5, 7, 12, 23, 25, 40, and 45 years) besides one profile irrigated with canal water and other profile from the virgin soil were found in the same area for both El-Gabal El-Asfar and Abu-Rawash. Water samples were collected from sewage drain and from canal water. Samples from vegetable crop of cabbage plant, woody trees (*E. camaldulensis* and *C. glauca*) and also some citrus trees (Naring, Orange and Lemon) grown in the different soils were analyzed for their content of heavy trace metals. Also, treated materials were collected for treating both treated sewage water and synthetic solution to remove heavy metals as (Pb, Cd, Ni, Co, Cr, Zn, Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup> and SO<sub>4</sub><sup>2--</sup>)

**The obtained results showed that:**

A very slight variation in texture was observed upon irrigating soil with sewage water especially soils irrigated for 40 and 45 years, as soil texture was loamy sand in the canal water irrigated and the virgin soils and sand clay loam in soils irrigated for 40 and 45 years with sewage water

Organic matter content is generally higher in soils irrigated with sewage water than those irrigated with canal water or virgin soils and tended to accumulate in the surface layers.

Irrigating soils with sewage water decreased  $\text{CaCO}_3$  content and pH of the surface layers, generally there was an increase in EC values of the soils irrigated with sewage water than those of the irrigated canal or virgin soils.

In respect to DTPT and/or  $\text{HNO}_3$ -extractable, heavy metals (Fe, Cu, Mn, Zn, Pb, Cd, Ni, Co and Cr) in both soil cultivation with (Citrus and Woody) trees and soil cultivation with cabbage plant which irrigated with sewage water at different periods under investigation, increased as the irrigation periods increased. The region of cultivated with (Citrus and Woody) trees maintained higher heavy metals concentrations than the region of soil cultivated with cabbage plants.

Data indicate that the bioavailability of trace elements to plant can be varying according to plant species. Plant heavy metals were concentrated mainly in the edible parts of cabbage plants and citrus trees. However, their accumulation in cabbage leaves are higher than citrus trees leaves. *E. camaldulensis* and *C. glauca* were capable of taking heavy trace metals, so, they can be used as filters for the purification of sewage water and reduced of the spread of these pollutants in the soil.

Evaluating the treatment process of sewage water and waste water by using different treatment materials as Amberlite, CM-cellulose, Cellulose phosphate, Dowex, DEAE-cellulose and

water hyacinth at different heavy metals cations and anions were recorded under the study of three factors: time of shaking, pH of solution and the concentration of metal ions. Generally, uptake of metal ions increased by increasing the contact time, also, increases concentration increased the uptake percent metal ion except at high concentration remained constant according to Langmuir model while water hyacinth uptake percent of metal ions decrease by increasing the concentration. On the other hand, decreased pH increasing the uptake percent of Amberlite, CM-cellulose, Phosphate cellulose, Dowex and DEAE-cellulose. And the *vice versa*, uptake percent of water hyacinth increased by increasing pH values

Removal of some cations and anions from treated sewage water increased by increasing weight of different treatment materials.

# CONTENTS

List of Tables	
List of Figures	
ABSTRACT	1
Aim of the work	4
<b>CHAPTER I</b>	
<b>INTRODUCTIO AND LITERATURE</b>	
<b>I. 1. INTRODUCTION</b>	<b>6</b>
<b>I. 2. Sources of heavy metals</b>	<b>8</b>
I.2.1. Agricultural materials.	
I.2.2. Manufacture and disposal include	
I.2.3. Waste disposal	9
<b>I.3.Toxicity of some metal cations and anions</b>	
I.3.1.Lead toxicity:	
I.3.2.Zinc toxicity:	
I.3.3.Cadmium toxicity:	10
I.3.4. Chromium toxicity:	11
I.3.5. Cobalt toxicity:	
I.3.6.Nickel toxicity: -	
I.3.7. Chloride toxicity: -	12
I.3.8. Sulphates toxicity: -	
<b>I.4. Ion exchange materials for waste water treatment</b>	<b>13</b>
<b>I.4.1 Natural exchange materials:</b>	
I.4.1.1. Clay minerals:	14
I.4.1.2. Wood:	15
<b>I.4.2. Synthetic ion exchange materials</b>	
I.4.2.1. DEAE-cellulose	
I.4.2.2.: CM-cellulose	16
I.4.2.3. P- cellulose	
I.4.2.4. Resins	
<b>I.2. LITEATURE SURVEY</b>	<b>17</b>
<b>I.2.1. Heavy metals and water:</b>	
I.2.1.1. Heavy metals in fresh water:	18
I.2.1.2. Heavy metals in sewage water:	23
I.5.1.3. Removal of toxic elements using ion exchange materials:	25

<b>I.5.2. Literature Survey on Soil:</b>	34
I.5.2.1. Effect of sewage water on some physical properties of the soil.	
I.5.2.2 Effect of sewage water on some chemical properties of soil:	36
I.2.2.3. Effect of sewage water on the accumulation of heavy metals by soil:	38
<b>I.5.3. Sewage Water and plants:</b>	42
I.5.3.1. Accumulation of heavy metals in plants:	
I.5.3.2. Effect of sewage water on the accumulation of heavy metals by plant:-	46
I.2.3.3. The translocation of metals through the different parts of plants:	50
I.5.3.4. Sewage risk reduction plantation of woody trees	53

## **CHAPTER II EXPERIMENTAL**

<b>II.1. Materials and Methods</b>	59
II. 1.1. Water Samples:	59
II.1.2. Soil Samples:	60
II.1.2.1. DTPA soil test:	62
II.1.2.2. 0.5 M nitric acid extraction	63
II.1.3. Plant sampling and analysis	64
<b>II.2. Materials: -</b>	64
II.2.1. Synthetic solution	65
II.2.2. Treated sewage water	66
II.3. Treatment technique	66
II.4. The studied metals	67

## **CHAPTER III**

### **RESULTS & DISCUSSION**

III. 1. WATER	68
III.1.1 The physical and chemical characteristics of sewage water that were used for irrigation at El-Gabal El-Asfar.	68
III.1.2. The physical and chemical characteristics of sewage water that were used for irrigation at Abu-Rawash	77
III. 1.3. The physical and chemical characteristics of sewage water of Alexandria City	84
Comparison between level of heavy metals in sewage water at both of El-Gabal El-Asfar; Abu-Rawash and Alexandria during the winter and summer seasons	85
III.1.4. The physical and chemical characteristics of canal water used for irrigation at Abu-Rawash	92
III.1.5. The physical and chemical characteristics of groundwater used for irrigation at Abu-Rawash	98
<b>III. 2. Soil</b>	
III.2.1. Effect of sewage reuse on some physical and chemical characteristics of soil at El-Gabal El-Asfar farm:	104
III.2.2.Effect of sewage reuse on some physical and chemical characteristics of soil at Abu-Rawash farm	108

III.2.3. Level of heavy metals in the agriculture soil as extracted by DTPA and 0.5 M HNO <sub>3</sub> at both of El-Gabal El-Asfar and Abu-Rawash regions	112
--	-----

### **III.3. PLANTS**

III.3.1. Effect of irrigation with sewage water on the macro-,micro-elements and heavy metals content in different species of citrus trees at El-Gabal El-Asfar farm:	126
---	-----

#### **III.3.1.1. Naring Citrus Tree:**

<b>III.3.1.2. Orange Citrus Tree:</b>	135
---------------------------------------	-----

<b>III.3.1.3. Lemon Citrus Tree:</b>	143
--------------------------------------	-----

III.3.2. Effect of irrigation with sewage water on the micro-, macro-elements and heavy metals content in different species of citrus tree fruits at Abu-Rawash region:	
---	--

III.3.2.1. Iron in the citrus plant irrigated with sewage water:	151
---	-----

III.3.2.2. Manganese and other heavy metals.	152
--	-----

III.3.3. Effect of irrigation with sewage water on the macro-, microelements and heavy metals content in Cabbage plants at El-Gabal El-Asfar farm:	172
--	-----

III.3.4. Effect of irrigation with sewage water on the macro-, microelements and heavy metals content in Cabbage plants at Abu-Rawash farm	176
--	-----

III.3.5. Effect of irrigation with sewage water on heavy metal content in Eucalyptus camaldulensis and Casuarina glauca trees at El-Gabal El-Asfar region (during the period from November 1999 to March 2001)	180
---	-----

III.3. 6. Effect of irrigation with sewage water on heavy metals content in Eucalyptus camaldulensis and Casuarina glauca trees at Abu-Rawash region (during the period from November 1999 to March 2001)	183
III.4. Results of sorption experiments	187
III.4.1. Determination V/m ratio	
<b>III.4.2. Sorption behaviour of heavy metals</b>	
III.4.2.1. Effect of contact time on uptake percent of lead: -	188
III.4.2.2. Effect of concentration on uptake percent of lead	
III.4.2.3. Effect of pH on uptake and capacity percent of lead: -	189
III.4.2.4. Effect of contact time on uptake percent of cadmium:	
III.4.2.5. Effect of concentration on uptake percent of cadmium	193
III.4.2.6. Effect of pH on uptake and capacity percent of cadmium	
III.4.2.7. Effect of contact time on uptake percent of zinc	
III.4.2.8. Effect of concentration on uptake percent of zinc	197
III.4.2.9. Effect of pH on uptake and capacity percent of zinc	
III.4.2.10. Effect of contact time on uptake percent of nickel: -	
III.4.2.11. Effect of concentration on uptake percent of nickel	201
III.4.2.12. Effect of pH on uptake and capacity of nickel	
III.4.2.13. Effect of contact time on uptake percent of cobalt	
III.4.2.14. Effect of concentration on uptake percent of cobalt	205
III.4.2.15. Effect of pH on uptake and capacity percent of cobalt	
III.4.2.16. Effect of contact time on uptake percent of chromium	209
III.4.2.17. Effect of concentration on uptake percent of chromium	



III.4.2.18. Effect of pH on uptake and capacity percent of chromium	210
III.4.3. Sorption behaviour of chloride, nitrate and sulphate ions on different materials	
III.4.3.1. Effect of contact time on uptake percent of chloride	213
III.4.3.2. Effect of concentration on uptake percent of chloride	
III.4.3.3. Effect of pH on uptake and capacity percent of chloride	214
III.4.3.4. Effect of contact time on uptake percent of nitrate	217
III.4.3.5. Effect of concentration on uptake percent of nitrate	
III.4.3.6. Effect of pH on uptake and capacity percent of nitrate	218
III.4.3.7. Effect of contact time on uptake percent of sulphate	221
III.4.3.8. Effect of concentration on uptake percent of sulphate	
III.4.3.9. Effect of pH on uptake and capacity percent of sulphate	
<b>III.4.4. Application of different materials on the treated sewage water by using batch technique</b>	<b>225</b>
III.4.4.1. Treatment of Lead	
III.4.4.2. Treatment of Cadmium	
III.4.4.3. Treatment of zinc	
III.4.4.4. Treatment of nickel	
III.4.4.5. Treatment of cobalt	226
III.4.4.6. Treatment of chromium	
III.4.4.7. Treatment of chloride	227
III.4.4.8. Treatment of nitrate	
III.4.4.7. Treatment of sulphate	228
<b>Summary and Conclusion</b>	<b>232</b>
<b>References</b>	<b>239</b>
<b>Appendix</b>	
<b>Arabic Summary</b>	