Chemical and Phytoremediation Studies on the Treatment of Industrial Wastewater

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By

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ABSTRACT

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The use of living plants and /or non-living plants biomasses is an attractive option for the treatment of industrial wastewater and removal of a large number of different contaminants in an environmental friendly way. In the first part of this study, wastewater, sediment and *Typha domingensis* plant samples were collected from the industrial zone at El-Sadat city in Egypt. Samples analyses revealed that wastewater samples contained aluminium, iron, zinc and lead ions with concentrations exceeding the permissible limits set by the Egyptian environmental laws. It has been found that *Typha domingensis* growing in the study area was capable of accumulating the studied metal ions preferentially from water than from sediments. The accumulation of metals by plant was restricted to its roots as the translocation factor was less than unity. Rhizofiltration was found to be the best mechanism to explain *Typha* phytoremediation capability. In the second part of the study, the effectiveness of *Typha domingensis* leaf powder for simultaneous removal of Al, Fe, Zn and Pb from aqueous solution was assessed. Batch experiments were carried out. The sorption process was found to be best described by the second order rate kinetics. The applicability of three equilibrium isotherm's models was investigated and was found to follow the following order: Langmuir > Freundlich >Temkin, for all the studied metal ions. A full 2^3 factorial design was then employed to obtain the best conditions of biosorption. Three factors were screened namely: temperature, pH, and biosorbent dosage. The factors were varied at two levels for each. The effects of each factor as well as the interaction effects of the factors on the biosorption process were obtained. The pH was found to be the most significant factor for the metal ions uptake. The infrared spectra of native and exhausted *Typha* leaf powder confirmed ions-biomass interactions responsible for sorption. Scanning electron micrographs confirmed the porous nature of the biosorbent surface.

Keywords: Sadat city; *Typha domingensis*; bioconcentration factor; translocation factor; aluminium; iron; zinc; lead; rhizofiltration; biosorption; kinetics; equilibrium isotherms; factorial experimental design; elemental analysis; infrared spectra; scanning electron microscopy.

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CHAPTER 1

INTRODUCTION

Water quality management, water pollution control and environmental protection are the main issues to save our future. Survival of human beings mainly depends on how we manage and use the environmental resources today. Water is considered the most important natural resource for man to develop his prosperity as well as his essential needs.

Industrialization is considered the cornerstone of the development strategies due to its significant contribution to the economic growth and human welfare, however, in most developing countries it led to serious environmental degradation. The earnest intentions are now not only targeting the qualitative and quantitative treatment of the industrial wastes but also attempting to avert their hazards to human health and restoring the quality of the environment **(1).**

1. Performance of Manufacturing Industry in Egypt

As industry is a major contributor to the Egyptian economy, the rapid pace of industrialization in the last few decades has been remarkable. The Egyptian manufacturing sector is concentrated on quite a few industries. Seven industries account for over 80% of establishments in the manufacturing sector. The three largest industries are textiles, food and beverages, and furniture followed by non-metallic minerals, metal production, chemicals and basic metals.

Industry is the dynamic engine for growth essential to rapid economic and social development **(2)**. Figure (1.1) gives the number of enterprises for the different Egyptian industrial sectors.

Most of the manufacturing establishments in Egypt are located within the boundaries of large cities where the utilities and supporting facilities are available. The Egyptian government's policy during the last two decades was oriented to build new industrial communities to act as new poles of attraction to relief the fragile ecosystem of the Nile valley and Delta from over population, such as 10^{th} Ramadan, 6^{th} October, El-Sadat, Al-Obour, Badr and Borg El-Arab cities (Fig.1.2). The industrial activities in these new cities range from metal production, food processing, textile finishing, to plastics, chemicals and pharmaceutical and paper production **(3)**.

2. Fresh water supplies and wastewaters

It is well known that the water resources in Egypt are limited to the 55.5 billion m^3/ year, share of Egypt in the flow of the river Nile, the deep groundwater in the deserts (mostly non-renewable), and a few amount of rainfall in the northern coastal area and Sinai. Meanwhile, water demand is continually increasing due to population growth, industrial development, and the increase of living standards. Because of population growth, the per capita share of water has dropped dramatically to 800 m^3/capita, which, by international standards, is considered below the "Water poverty limit". The value may even decrease to 500 m^3/capita by the year 2025 **(4)**.

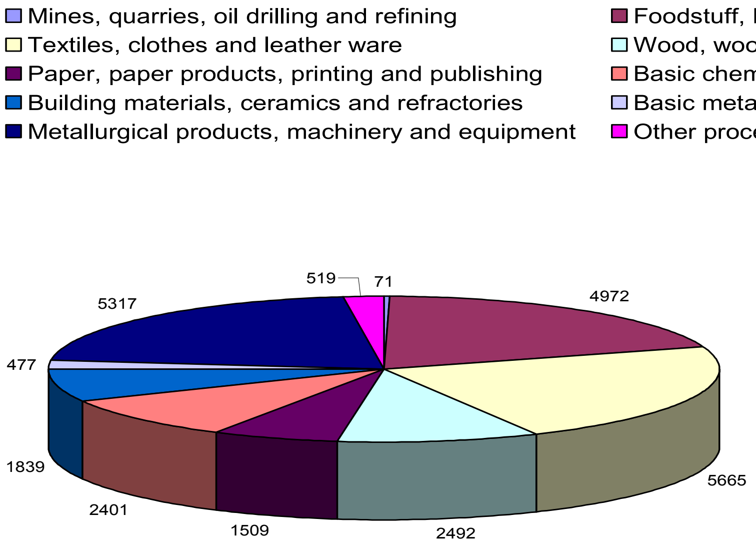

Fig. (1.1): Distribution of enterprises for the different industrial sectors in Egypt.

Fig. (1.2): Map of Egypt showing location of some new industrial cities.

Degradation of water quality is a major issue in Egypt. The severity of the problem varies among different water bodies depending on water flow, use pattern, population density, extent of industrialization, availability of sanitation systems and the social and economic conditions existing in the area of the water source. Discharge of untreated or partially treated industrial and domestic wastewater, leaching of pesticides and residues of fertilizers; and navigation are the most important factors that affect the quality of water **(5)**.

The industrial sector is an important user of natural resources and a contributor to environmental pollution. There are estimated to be some 24,000 industrial enterprises in Egypt, about 700 of which are major industrial facilities. The spatial distribution of industry in Egypt is influenced by the size of the employment pool, availability of services, access to transportation networks, and proximity to principal markets.

The manufacturing facilities are therefore often located within the boundaries of major cities, in areas with readily available utilities and supporting services. In general, the majority of heavy industry is concentrated in Greater Cairo and Alexandria.

Industrial demand for water in the year 2000 has been reported to be 3.6 billion m^3/ year. By the year 2017, the industrial demand for water is expected to reach 5.5 billion m^3/ year. Consequently, a corresponding increase in the volume of industrial wastewater is expected **(5)**.

3. Policies directed at industrial environmental management

The period 1990-2000 witnessed the most important environmental initiative in Egypt since the ratification of environment law 4/1994. This law generally prohibits the use of waterways for the disposal of solid wastes and the discharge of untreated liquid wastes from industries.