BIOREMOVAL OF HEAVY METALS AND ORGANIC MATTER FROM INDUSTRIAL WASTE WATER

BY

RASHA SAMIR AHMED MOHAMED
B.Sc. Agric. Sci. (Biotechnology), Fac. Agric., Cairo Univ., 2006

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APPROVAL SHEET

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Title of Thesis: Bioremoval of Heavy Metals and Organic Matter From Industrial Wastewater.

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ABSTRACT

This work deals with heavy metal removal from industrial effluents in order to reduce their negative impact on the environment. The biosorption capability for lead and chrome by different microorganisms was evaluated using batch system for synthetic heavy metal containing water and real wastewater effluents.

In the synthetic heavy metal containing batch, different concentrations of lead (50, 100, 500 ppm) or chrome (100, 500, 1000 ppm) were used to screen for microorganisms that have the efficient biosorption capability for each heavy metal. Among the identified isolates, the Nile sediment isolate mix had the maximum lead biosorption capability (96.5%) while the *Azotobacter chrococcum* strain had the highest chrome biosorption ability (88.51%).

In the lead containing waste water (battery industry wastewater), which have initial lead concentration 5 ppm, the treatment modifying the C:N:P ratio resulted in enhancing the lead removal (95.5%) and COD reduction (100% reduction) by the native microflora of the waste water.

In the chrome containing waste water *i.e.* tannery waste water, which have initial chrome concentration 3104 ppm, the treatment by adding of aerobic activated sludge removed almost all the chrome (99%) content and significantly reduced the COD levels by (89.9%).

Key words: Chrome biosorption, lead biosorption, tannery wastewater treatment, battery wastewater treatment.

DEDICATION

I dedicate this work to my lovely mother and my dear father who supported and helped me along my entire life, and gave me endless love that made me able to overcome difficulties I faced during the completion of this work.

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INTRODUCTION

The dramatic increase in volumes of organic and inorganic industrial wastes coincided with the extensive development of industrialization which resulted in over increase problem of environmental pollution. Apart from inorganic waste product deposed, heavy metals represent a serious group of pollutants introduced by man into the environment which causes hazards to human health, harm to living resources and ecological systems (Badawi, 2004).

The methods used for heavy metal removal from industrial effluents can be classified as physical, chemical and biological approaches. Physicochemical applications as precipitation, ion exchange, filtration, adsorption on activated carbon and reverse osmosis, etc. require high capital and operating costs and may also be associated with the generation of secondary wastes which cause treatment problems. Most recently, attention has been drawn toward development of alternative methodologies known as bioremediation processes. These technologies include, among other processes, biosorption. Biosorption is defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physiochemical pathways of uptake (Ansari *et al*., 2011).

In this study, biosorption is used for the removal of pollutants from waste waters contaminated with pollutants that are not being easily biodegradable, such as heavy metals. A variety of biomaterials are known to bind these pollutants including bacteria, fungi, algae and certain industrial and agricultural wastes such as tannery effluents, battery effluents…etc.

Biosorbents are less costly and more effective alternatives for the removal of metallic elements, especially heavy metals, from aqueous solution.

The major objective of this study is to screen in the collected isolates and strains for lead or chrome removal from solution. And then apply the potent strains to remove heavy metals (lead or chromium) from industrial wastewater to reduce their environmental hazardous impacts.

REVIEW OF LITERATURE

1- Hazards of heavy metals associated with industrial wastewater pollution

Tolga *et al.* (2007) stated that heavy metal pollution is an environmental problem of wide concern. Heavy metals released into the environment have been increasing continuously as a result of industrial activities and technological development, posing a significant threat to the environment and public health because of their toxicity, accumulation in the food chain and persistence in nature.

Heavy metals like lead, mercury, copper, cadmium and chromium are among the most common pollutants found in industrial effluents. Even at low concentrations, these materials can be toxic to organisms, including humans.

Water quality standards hand book, 2nd ed. (1993) listed that according to the drinking water quality standards, the levels of heavy metals in water should not exceed those limit if it used for human consumption as shown in Table (1).

Table.1. Standard values for maximum limits of heavy metals in drinking water

Metal	limit
Cd	10 µg/l
Cr	0.05 mg/l
Cu	1 µg/l
Ni	634 mg/l
Pb	50 µg/l

In addition according to Environmental requirements in Egyptian laws the parameters of industrial wastewater was as shown in Table (1.a).

Table 1.a. environmental requirements in Egyptian laws as regulated by law 48 for year 1962.

Parameter (mg/l)	Level in industrial wastewater
BOD_5	60
COD	100
pH	6-9
temperature(°C)	35
Total suspended solids	50
Total dissolved solids	2000
phosphate	10
Ammonia	-
nitrates	40
Total coliforms in 100 Cm^3	5000
chrome	1
lead	-
Organic compounds	absent
color	absent

Tolga *et al.* (2007) reported that heavy metals are discharged from various industries, such as electroplating, metal refineries, textile, mining, leather tanning, ceramic and glass. In addition many industries such as storage batteries, steel industries generate large quantities of wastewater containing heavy metals.

(a) Lead as a contaminant and removal from industrial wastewater

Tolga *et al.* (2007) indicated that lead is a naturally occurring element and nature has evolved with mechanisms to cope with its presence. A great deal is also known about lead from centuries of use and, indeed, this may largely be the reason for many present concerns. Lead (Pb^{+2}) is a heavy metal with atomic number of 82. Lead, an extremely toxic element, can cause damage to human nervous system, kidneys, and reproductive system, particularly in children.

Fulekar (2010) stated that Pb^{+2} heads the list of environmental threats because even at extremely low concentrations, it has been shown to cause brain damage in children.

Ridvan *et al.* (2001) studied biosorption of Pb^{+2} from artificial wastewaters onto dry fungal biomass of *Phanerochaete chryosporium* in concentration range of 5-500 mg/l. Maximum absorption of heavy metal ions on the fungal biomass was obtained at pH 6.0 and biosorption equilibrium was established after 6 hrs.

Dursun *et al.* (2003) stated that the effect of Pb^{+2} ions on growth and bioaccumulation prosperities of *Aspergillus niger* was obvious. Factors as pH, initial ion concentration were studied. The optimum pH values for growth and metal ion accumulation was determined as 4.5. Metal ion concentration used caused growth inhibition effect to *A. niger* which was capable of removing of Pb^{+2} with a maximum specific uptake capacity of 34.4 mg/g at 100 mg dm^{-3} initial lead concentration .

In a study conducted by Selatina *et al.* (2003) on lead biosorption capacity of *Streptomyces rimosus*, the biomass was treated with 0.1*M* NaOH and biosorption was studied in batch mode. The optimum biomass particle size was found between 50-160 *µm*, an optimum contact time was 3 h, the optimum biomass concentration was 3 g/l and the optimum stirring speed was 250 rpm. Under these optimal conditions, a maximum removal of 135 mg Pb^{+2}/g biomass was obtained.

Masud and Anantharaman (2006) studied the bacterial growth and lead (IV) biosorption using *Bacillus subtilis*. They used 4 lead concentrations *i. e* 500, 600, 700 and 800 ppm where they noted a remarkable growth in the four concentrations but growth was decreased by further increases in lead concentration. They concluded that *Bacillus subtilis* was an effective biosorbent of lead (IV) particularly when the maximum bacterial growth approximated $4.9x10^8$ cell/ml and the maximum biosorption reached up to 97.68% (w/w) in a batch containing 700 ppm lead after 48 h incubation.

Candidia albicans was able to remove Pb^{+2} ions from aqueous solutions in a batch system biosorption. Extended metal ion removal increased with increasing contact time, initial metal ion concentration, and temperature. Biosorption equilibrium was observed after 30 min; the maximum biosorption capacity of Pb^{+2} on *C. albicans* was determined as 8.31 +/- 1.12 mg/g at 35ºC and the optimum initial pH for Pb^{+2} was pH 5.0 (Baysal *et al.*, 2009).

Fulekar (2010) suggested that biosorption of Pb^{+2} ions by orange peels can be an inexpensive and effective way of metal ion