# IN-VITRO TREATMENT OF POLLUTED WATER BY SAW-DUST

N. PRIYANTHA, T. P. ABEYSINGHE AND S. KEERTHIRATNE

*Department of Chemistry, Faculty of Science, University of Peradeniya.*

## ABSTRACT

Investigation of the potential ability of economical and readily available naturally occurring substances such as saw-dust for treatment of polluted water is performed. In-vitro treatment of water samples with added pollutants, that are found in many polluted waters, reveals that the saw-dust of *Albizia Odoratissima* ("mara" in Sinhala) is able to remove many metal ions such as magnesium, calcium, chromium, manganese, iron, cobalt, copper, zinc, cadmium and lead from polluted waters. However, water samples treated with mara saw-dust for colour removal is not clear enough to be discharged into surface water without further treatment. Nevertheless, such methodology offers unique advantages of treatment of polluted water in developing countries.

## INTRODUCTION

Growth of industries and population in urban areas has posed serious problems on water quality. Although many industries require large quantities of water per unit weight of produce, a substantial portion of intake is thrown out as effluent which is contaminated with several substances. The presence of these contaminants and domestic waste, changes physical, chemical as well as biological state of water. Consequently, harmful effects, such as unbalancing solution pH, death of aquatic life, increase in different pathogenic organisms and adverse effects to humans would result.(Bordons and Jofre, 1987, Dissanayake, Niwas and Weerasooriya, 1987, Seneviratne, 1992, and Manahan, 1994). Sri Lanka Standards Institute (SLSI) and the Central Environmental Authority (CEA) with the recommendation of the World Health Organization (WHO) have thus enforced guide lines for surface water.

Adsorption processes have been attractive in recent years as an effective means of decreasing concentrations of coloured molecules and ionic species in waste water (Marzal et al, 1996). Activated carbon, peat, colloids, sand, rice husks and bauxite have already been reported as colour adsorbents (Tunay et al.,1996). Electrolytic precipitation and chlorination are also used in the colour removal process of effluent water (Davis and Burns, 1990).

Among the various methods available for metal ion removal, coagulation and precipitation, lime treatment, reverse osmosis, ion exchange and adsorption processes have been widely applied (Sulette Sinder and Sylvester, 1982, Wong Lam and So, 1993, Zhou and Zimmermann, 1996, Davis and Burns, 1992). Recent accomplishments in this area of research include the use of decaying leaves, immobilized cells, carbon-based substances and clay-based substances for effective removal of metal ions (Salim and Robinson, 1982, Venkateswerlu and Sttzky, 1989, Salim, Al-Subu and Qashoa, 1994, Baes, Umali and Mercado, 1996, Qiaoand Ho, 1996, Sayrafi, Salim and Sayrafi, 1996, Sergreev, Shimko and Kuleshova, 1996).

The goal of this research is to investigate the use of saw-dust for colour and metal ion removal from polluted water. Optimization of experimental/column parameters of saw-dust, followed by in-vitro treatment of coloured solutions and ionic solutions were conducted. Environmental friendliness, low-cost and readily availability are some additional features of saw-dust based methods for treatment of polluted water.

## MATERIALS AND METHODS

### Materials

Saw-dust of Albizia Odoratissima (Mara) was collected from a saw mill located at Pilimathalawa. They were separated into desired sizes. Stock solutions of metal ions were prepared by dissolving analytical grade chemicals [$MgSO_4.7H_2O$, $CaCO_3$, $K_2CrO_4$, $KMnO_4$, $FeSO_4$, $Co(NO_3)_2$, $CuSO_4$, $ZnSO_4$, $CdSO_4$ and $Pb(NO_3)_2$], purchased from the British Drug Houses Ltd., England, in deionized water. Small amounts of either concentrated HCl or concentrated $HNO_3$ were used when solubility problems were encountered. Diluted standard solutions of individual metal ions prepared using appropriate volumes of each stock solution and deionized water. Methylene blue model dye was purchased from Hemas Drugs, Ltd. Untreated, blue coloured textile effluent samples were obtained from Osprey Garment (Pvt) Ltd., Ranala, Sri Lanka, while the plant was in operation.

### Instrumentation

Atomic absorption spectrometer (Buck Instruments Model 200-A) was used to record absorbance measurements of each metal ion solution, in triplicate, at a selected wavelength using an appropriate hollow cathode lamp. Pure acetylene and air were used as the fuel and the oxidant, respectively. Shimadzu uv/vis spectrophotometer (model 1601) was used for all colorimetric measurements which were recorded on a Panasonic KX-P1080i printer. Saw-dust particles were separated into desired sizes using a set of sieves attached to a vibrator.

### Research design

Most of the optimization experiments for colour removal were conducted by placing 50 ml methylene blue dye in a beaker (static conditions). Absorbance measurements before and after treatment were taken in triplicate and the average values were reported. Atomic absorption measurements of metal ion solutions before and after treatment with saw-dust particles were recorded by passing standard solutions of individual metal ions of different concentrations (2.0, 4.0, 6.0, 8.0, and 10.0 mg/L) through saw-dust packed glass columns (dynamic conditions). Since the working concentration range of a species depends on the linear dynamic range of atomic absorption detection, standard solutions and corresponding treated standards of **Mg, Ca, Mn, Fe, Cu, Zn and Cd** ions were diluted by an appropriate volume factor with deionized water until absorbencies fell within the linear range. Absorbance measurements of solutions of **Cr, Co and Pb** ions were recorded without any further dilution as the concentration range of 2.0 to 10.0 mg/L is in the linear range of detection. The experimental/column parameters such as medium, amount of adsorbent, particle size, solution pH and flow rate were optimized for colour removal processes.

## RESULTS AND DISCUSSION

Methylene blue and blue coloured textile effluents show maximum absorbance at the same wavelength of 665 nm and, consequently, this wavelength and methylene blue (as the model dye) were selected for all optimization experiments.

### Optimization experiments for the colour removal process

#### Medium

Methylene blue solutions showed a significant change in absorbance after treatment with saw-dust regardless of the medium in which the solution was prepared (Table 1).

**Table 1. Percent change in absorbance measured at 665 nm in solutions of 5.00 g saw-dust mixed with 100 ml solutions. Equilibration time 1.0 hr.**

| Solution | % change |
|---|---|
| distilled water | 54.5 |
| boiled water | 46.4 |
| dil HCl | 37.6 |
| dil NaOH | 64.8 |

Although treatment in the basic medium resulted in a greater change in absorbance, the solution turned brown in colour after treatment. Distilled water is thus selected as the medium of choice for further experiments.

#### Amount of adsorbent

Absorbance was drastically decreased when the amount of saw-dust particles added to the methylene blue solution (50 ml) was increased, as expected (Fig. 1). As it is not desirable to use larger quantities of adsorbents in treatment of real samples, a compromise value of 2.5 g is recommended for 50 ml of methylene blue solution for further optimization experiments.

#### Particle size

This is an important parameter as the size of a particle is related to the surface area of the treatment system. Although smaller particles show more significant changes in colour intensity according to visual observations, smaller changes in absorbencies were recorded due to turbidity (Fig. 2). It should be noted that percent change in absorbance and percent colour removal are the same as the concentration of the coloured substance is directly proportional to absorbance according to the Beer's law. Particles that result in turbidity less than 12 NTU are therefore selected (1.00 mm, 1.25 mm, 1.40 mm, 1.80 mm and 2.00 mm) for further control experiments.

**Solution pH**

All attempted particle sizes showed a significant colour removal up to pH 9, and the efficiency of colour removal then dropped drastically (Fig. 3). The pH range from 6 to 8 is thus recommended as the optimum pH range as it is more practical to work at pH values in the vicinity of the neutral value.

**Concentration of the dye solution**

The rate of change in absorbance was increased as the concentration of the dye solution was increased indicating higher percent colour removal efficiencies can be obtained at higher concentrations (Fig. 4). Among the concentrations that lead to more than 70% colour removal efficiencies, the concentration of 3.0 ppm is selected as the colour intensity of methylene blue solution of this strength and that of textile effluents is about the same according to visual observations.

**Flow rate**

Percent change in absorbance estimated at different flow rates using glass columns packed with saw-dust particles of different sizes (1.25 mm, 1.40 mm, 1.80 mm) indicated that the percent colour removal was greater than 80% at flow rates ranging from 10 ml/min to 50 ml/min. How ever, a moderate value of 30 ml/min is selected as the optimum value.

**Ion removal experiments**

All ion removal experiments were conducted in columns packed with saw-dust particles of desired sizes as such systems can easily be extended to real applications. According to optimization experiments of colour removal, medium, and particle size for ion removal experiments are selected to be distilled water and 1.25 mm, respectively. The optimum flow rate for ion removal experiments was selected to be 30 ml/min.

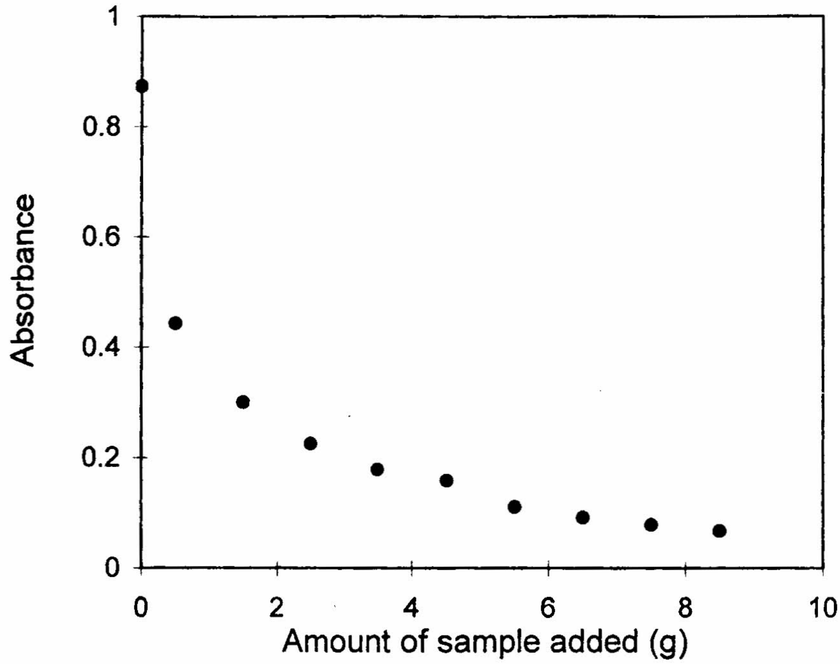



Fig. 1. **Variation of absorbance of methylene blue solution (3 ppm) with the amount of saw-dust.**

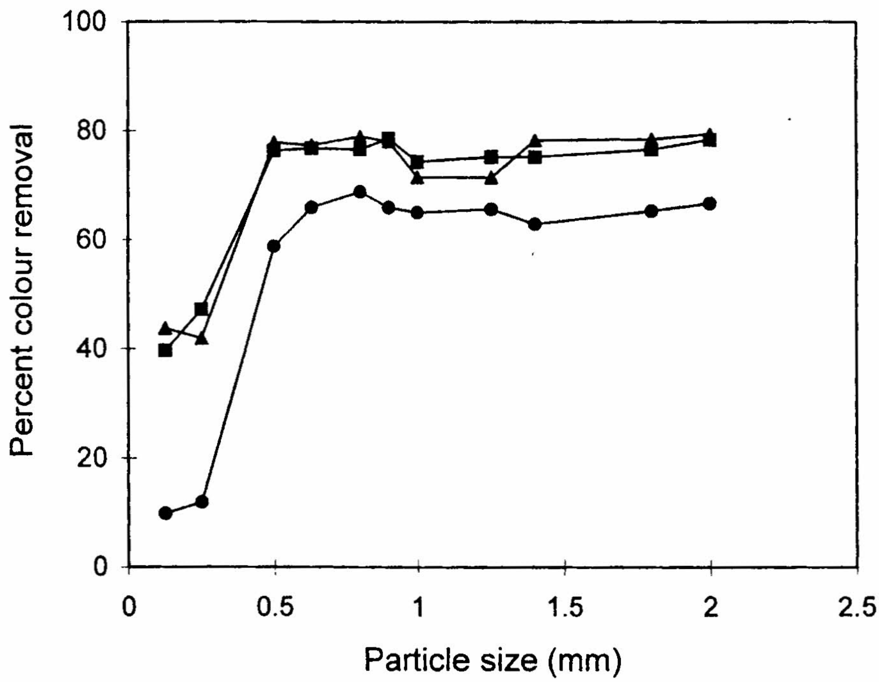



Fig. 2. **Variation of percent colour removal of methylene blue solution (3 ppm) with the size of saw dust particles after 1 hr (●), 2 hrs (■), 3 hrs (▲) of treatme**

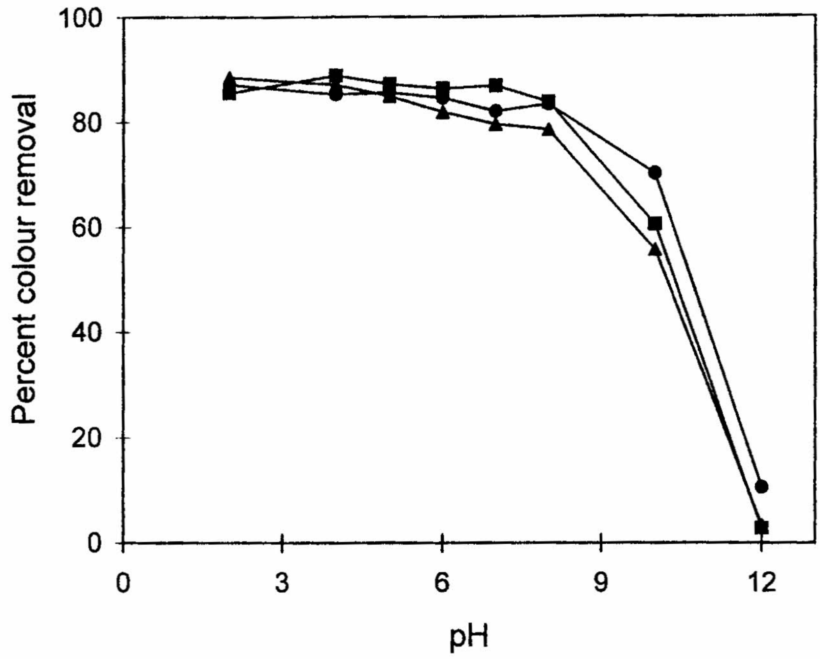



Fig. 3. **Percent colour removal at different pH values with saw-dust packed columns. Particle size: ( ■ ) 1.00, ( ● ) 1.25 mm ( ▲ ) 1.40 mm.**

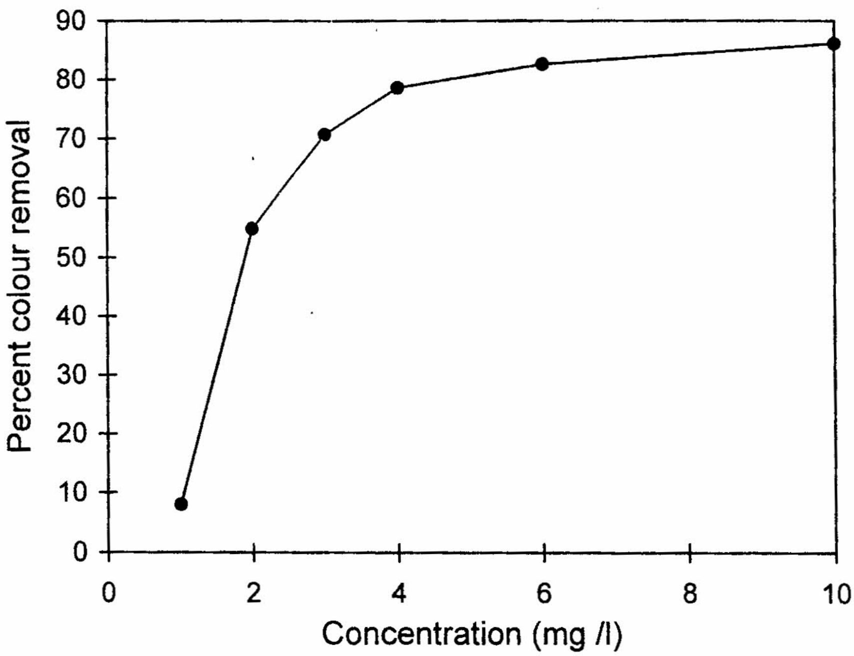



Fig. 4. **Percent colour removal at different concentrations of methylene blue model dye.**

Percent removal of metal ions calculated using absorbance changes before and after treatment of ion solutions with saw-dust packed columns demonstrate the ability of saw-dust for removal of many metal ions (Fig. 5 - 9). Among the metal ions investigated, saw-dust packed columns offer the highest efficiency for removal of cadmium and lead from aqueous solution. Preferential adsorption of cadmium and lead over the other metals would be the reason for this selective treatment. Other metals such as manganese, cobalt, copper and zinc can also be removed significantly at low concentrations using saw-dust packed columns. Magnesium, calcium, chromium and iron are more difficult to be removed from aqueous solution using saw-dust.

## CONCLUSIONS

Effective removal of metal ions such as manganese, cobalt, copper, zinc, cadmium and lead, and blue colour of methylene blue from aqueous solution is achieved using glass columns packed with saw-dust particles of *Albizia Odoratissima*. Such accomplishments lead to development of an alternative avenue of using filters packed with saw-dust particles for removal of heavy metal ions and colour present in industrial effluents. Environmental friendliness and cost effectiveness are added advantages of the proposed procedure. Use of other natural substances such as dolomite, clay, aquatic plants and plant materials for treatment of polluted waters and industrial effluents is the next logical step for this research.

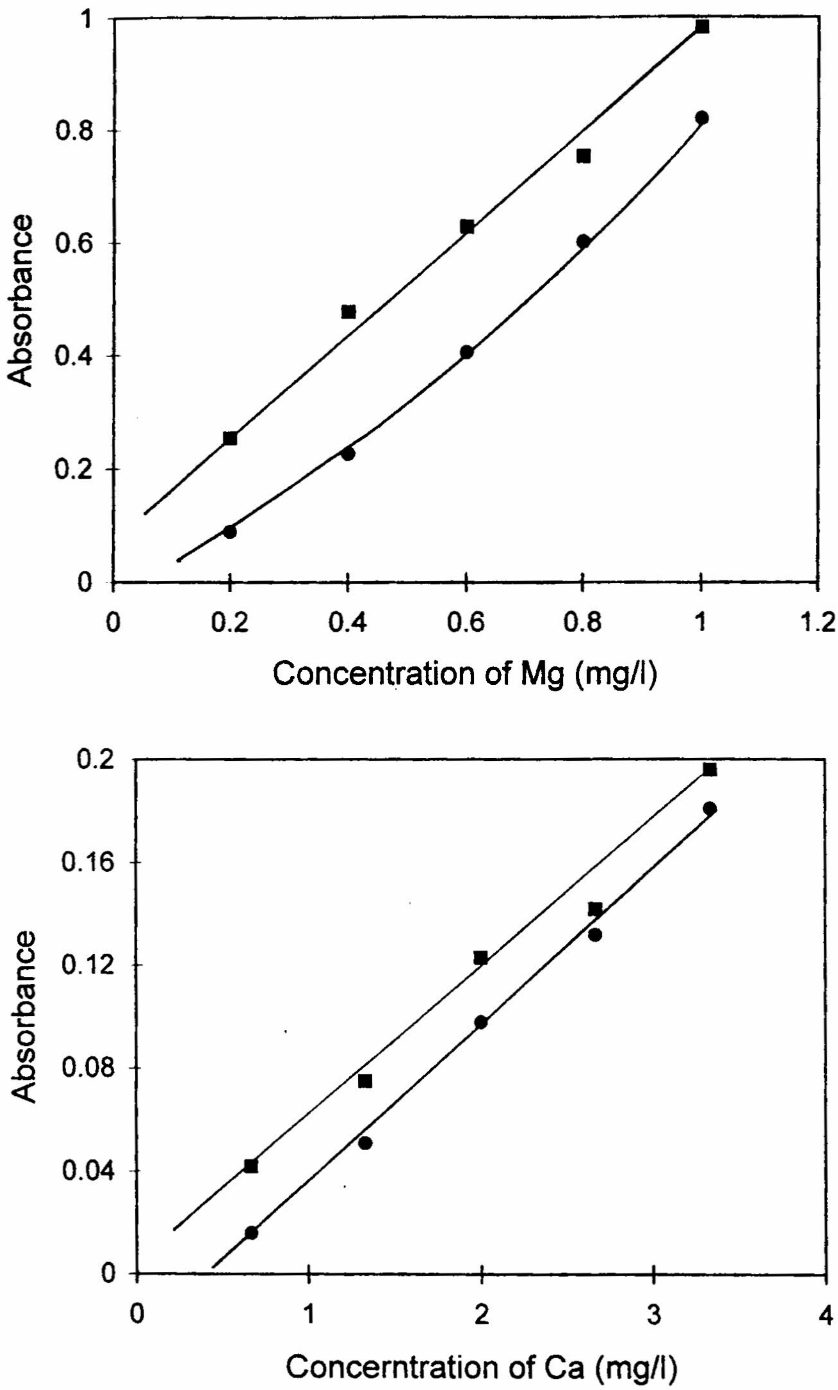
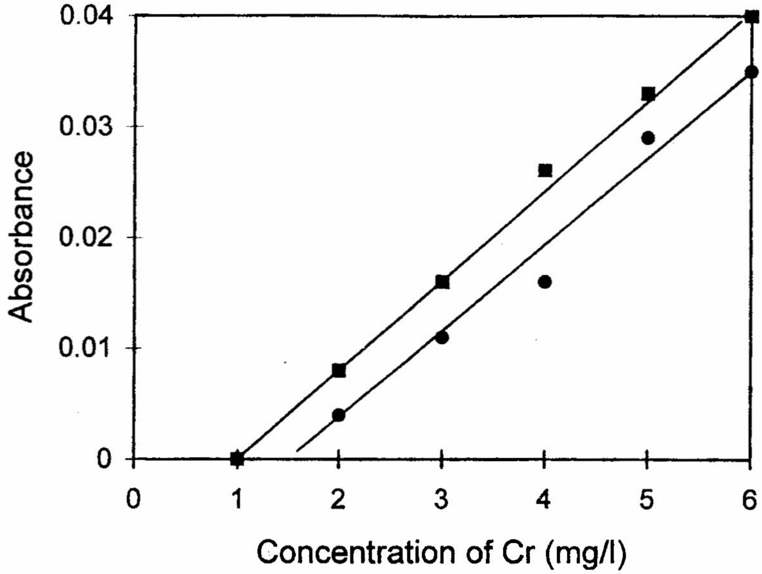



Fig. 5. **Absorbance of standard metal ion solutions before (■) and after (●) treatment with saw-dust particle packed columns. Mg (above) and Ca (below)**



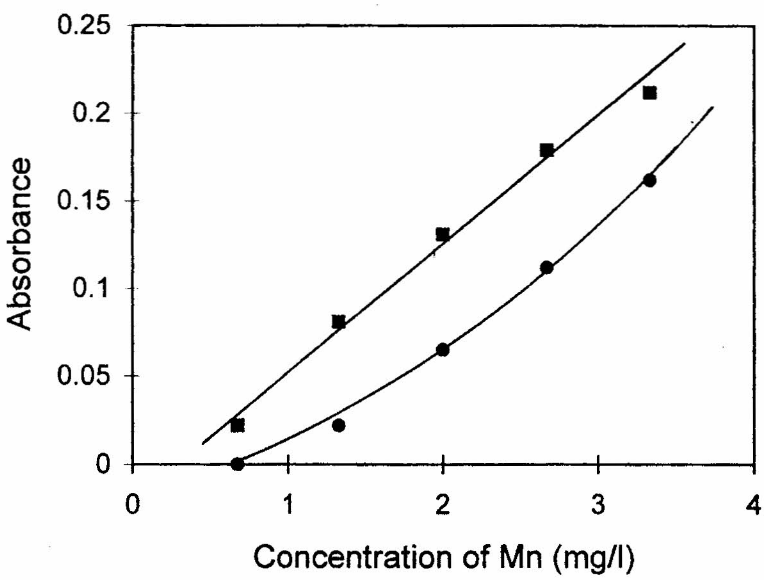
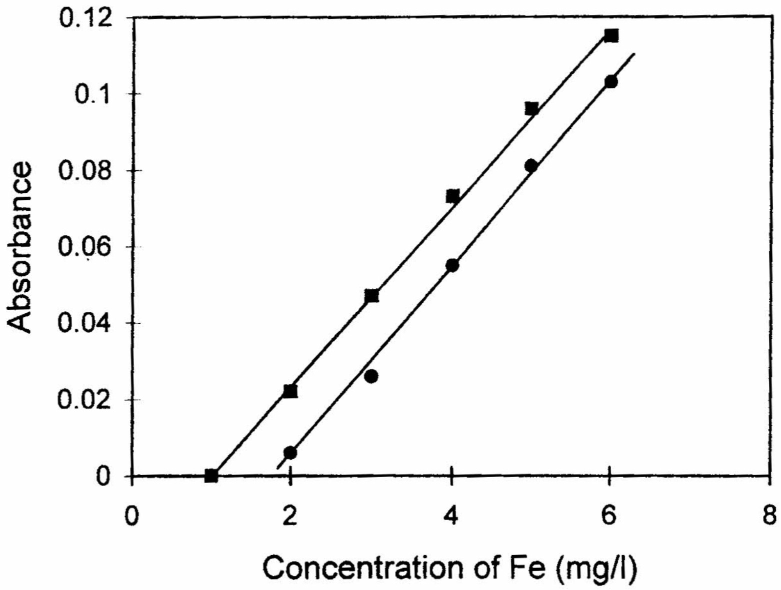




Fig. 6. **Absorbance of standard metal ion solutions before (■) and after (●) treatment with saw-dust particle packed columns. Cr (above) and Mn (below).**



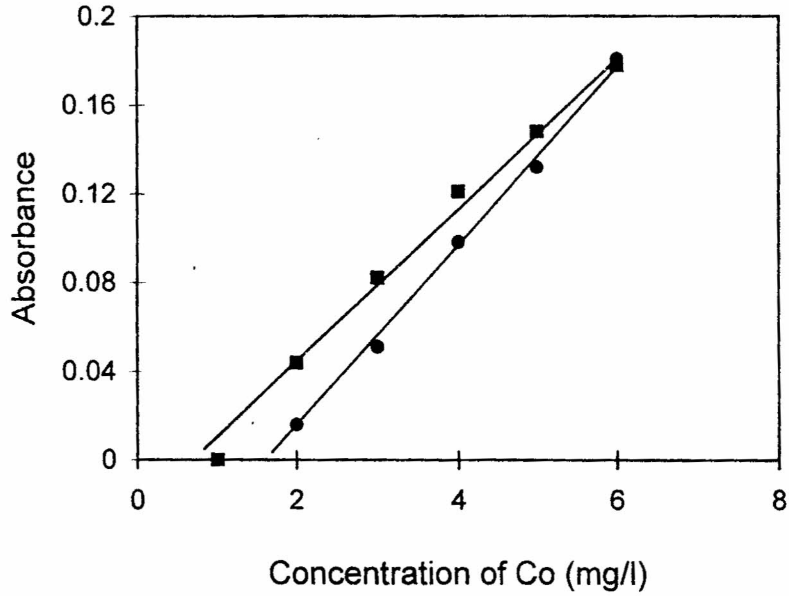
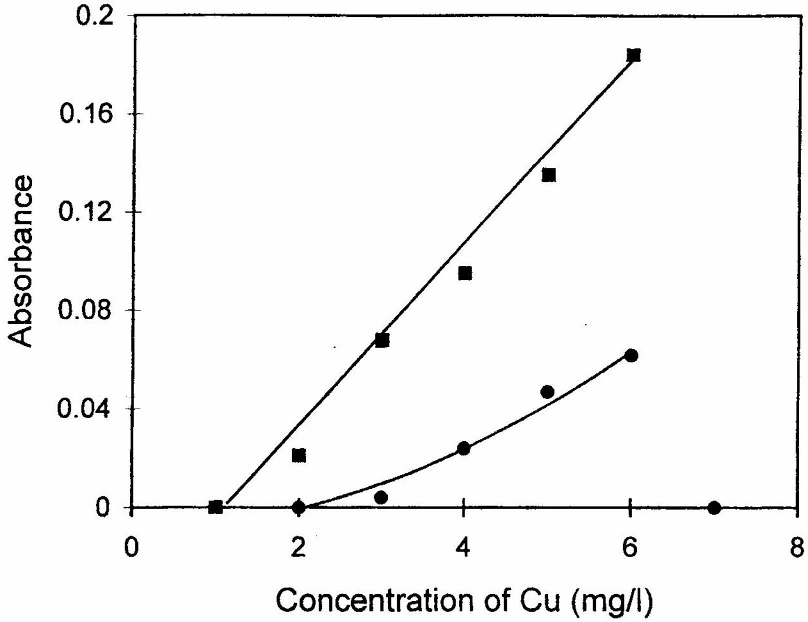




Fig. 7. **Absorbance of standard metal ion solutions before (■) and after (●) treatment with saw-dust particle packed columns. Fe (above) and Co (below).**



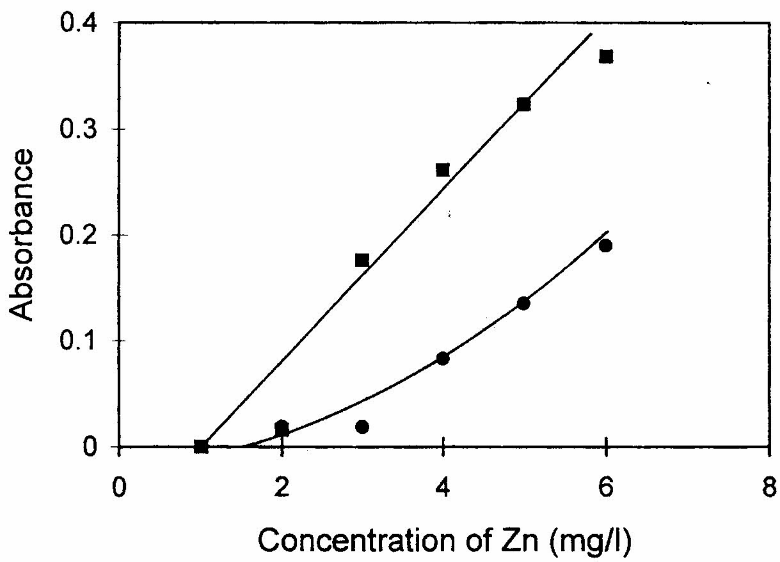




Fig. 8. **Absorbance of standard metal ion solutions before (■) and after (●) treatment with saw-dust particle packed columns. Cu (above) and Zn (below).**

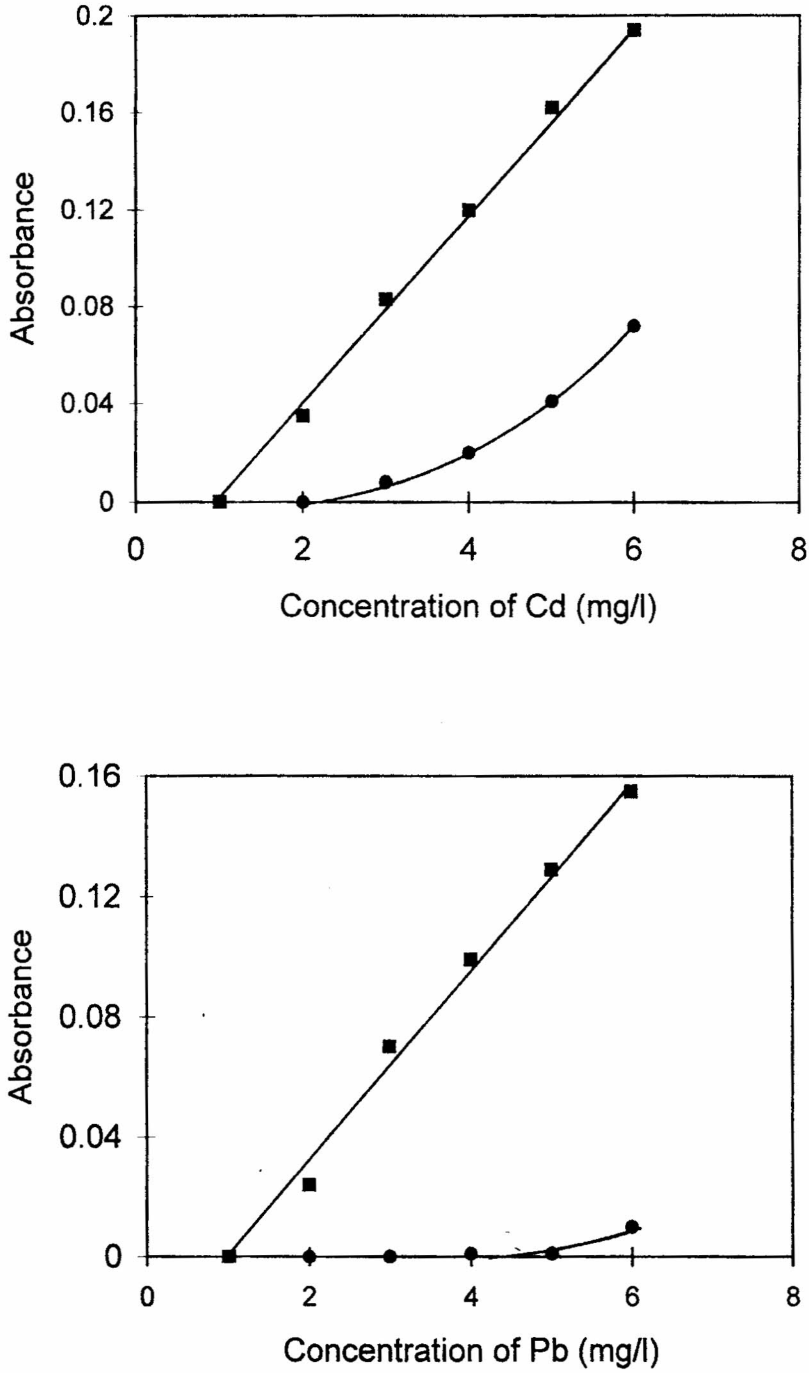



Fig. 9. **Absorbance of standard metal ion solutions before (■) and after (●) treatment with saw-dust particle packed columns. Cd (above) and Pb (below)**

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