

Sorption of Cadmium and Lead Ions by *Cunninghamella elegans* Lender ML2

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CUNNINGHAMELLA *elegans* Lender was isolated from agricultural field treated with sewage industrial effluents. It was selected on the basis of its high frequency for the biosorption potential evaluation of cadmium and lead. Alkali pretreated dead biomass was used for biosorption experiments. The effects of biomass concentration, initial metal concentration, pH, contact time, temperature and agitation rate were studied. The maximum uptake capacities of cadmium and lead ions are 59 mg/g and 71 mg/g dry wt biomass at initial concentration of metal ions 300 mg/L and 200 mg/L biomass dosage, respectively. The optimum pH values for cadmium and lead biosorption were 5.0 and 6.0. The best temperature was 25°C for cadmium and lead ions. Maximum uptake for cadmium was achieved after 60min, while for lead after 30 min. The best agitation rate was 120rpm for both metal ions removal. The technique of scanning electron microscope coupled with energy dispersive X-ray analysis (EDAX) shows that cadmium and lead were exchanged with elements present on the surface of native cells of *C. elegans* Lender ; thereby suggesting ion exchange as one of the dominant mechanisms of metal biosorption for this fungal strain. Alkali pretreated biomass was tested to remove cadmium and lead ions from three wastewater samples. Cadmium and lead ions were effectively eluted by 15 mM HNO₃ and 10 mM EDTA, respectively.

Keywords: Biosorption, Cadmium, Lead, Fungi.

Increased industrial and human activities have impact on environment through the disposal of industrial wastewater, sewage and sewage sludge to agricultural land. These wastewaters contain some plant nutrients, organic matter and varying levels of heavy metals (Hayat *et al.*, 2002 and Korboule *et al.*, 2002). The heavy metal pollution is an environmental problem of world wide concern. The big three metals known for their high toxicity and public health risk problems are lead, mercury and cadmium (Volesky, 2007). Cadmium compounds were currently mainly used in rechargeable nickel-cadmium batteries. Cadmium emissions had increased dramatically during the 20th century, one reason being that cadmium containing products were rarely recycled, but often dumped together with household waste. The adverse health effects due to cadmium

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exposure may occur at lower exposure levels than previously anticipated, primarily in the form of cancer, but bone fractures, and kidney damage are also possible (Järup, 2003). Lead is extremely toxic and can damage the nervous system, kidney and reproductive system, particularly in children (Sheng *et al.*, 2004 and Gavrilescu, 2004).

Biosorption is a property of certain types of inactive, non-living microbial biomass to bind and concentrate heavy metals from even very dilute aqueous solutions (Ahluwalia & Goyal, 2007). They added that, biosorption mechanisms are various and in some cases they are still not very well understood. They may be classified according to the dependence on the cells' metabolism; active and passive biosorption and the location where the metal removed from the solution is found (extracellular accumulation/precipitation, cell surface sorption/precipitation and intracellular accumulation).

Many microbial species such as algae, bacteria and fungi are known to have high metal adsorbing capacities (Selatnia *et al.*, 2004a and Chen & Lian, 2005). Vijayaraghavan & Yun (2008) reported that the removal of pollutants from waters (industrial and agricultural wastes), especially these that were not easily biodegradable such as metals and dyes, a variety of biomaterials were known to bind these pollutants, including bacteria, fungi and algae. Fungi are better suitable for the removal of metals from wastewater than other microbes because of their great tolerance towards heavy metals and other adverse conditions such as low pH, high chitin content in cell walls, and this polymer of N-acetylglucosamine is an effective metal and radionuclide biosorbent (Tobin *et al.*, 1994). El-Morsy (2004) reported that *C. echinulata* could be employed either in free or immobilized form as a biosorbent of metal ions in wastewater. *Schizophyllum commune*, *Ganoderma lucidum* and *Pleurotus ostreatus* have been also reported as an efficient biosorbents for copper and nickel in relation to chromium and zinc ions from electroplating effluents (Javaid & Bajwa, 2008).

Living and dead cells of fungi are able to remove ions of heavy metals from aqueous solutions (Kapoor & Viraraghavan, 1995 and Volesky & Holan, 1995). There is a number of advantages associated with the use of dead (inactive) biomass such as toxicity of the metals in solution cannot affect the adsorptive function of the biomass, nutrient and other biomass growth requirement do not need to be satisfied in the process, and maintenance of the purity of the culture is not a concern (Bayramoglu *et al.*, 2005). Another advantage of using dead biomass was the sorbed metal ions could be easily desorbed and the biomass could be reused (Selatnia *et al.*, 2004b). The alkali pretreatment was observed to be most effective in increasing the biosorptive capacity of fungal biomass (Göksungur *et al.*, 2005). Also, Amini *et al.* (2008) studied the outer surface, microporosity and pore size of the non-viable *A. niger* after treatment by NaOH using scanning electron microscope. They reported that lead biosorption capacity on dead *A. niger* biomass was enhanced by that treatment.

The aim of the present work is the isolation of novel fungal organism for use as a biosorbent and optimization of conditions for use of its biomass to remove cadmium and lead from industrial wastewaters.

Materials and Methods

Heavy metals analysis of soil

Agricultural field soil of Meet Abou Khalide (Dakahlia Governorate, Egypt) receiving long term application sewage and industrial effluents as irrigant was analyzed for heavy metal content and was used to isolate fungi by spread plate method. For analysis of heavy metals contents, samples were prepared according to the standard method as described by Vanloon & Lichwa (1973) using atomic absorption spectrophotometer (Model Unicam 969).

Isolation and identification of fungi

For the isolation of fungi, sabouraud dextrose agar (SDA) medium supplemented with CdCl_2 / $\text{Pb}(\text{NO}_3)_2$ at 50 $\mu\text{g/ml}$ conc. at 45-50°C before pouring the medium into petriplates (Ahmed *et al.*, 2005). 0.1 gm of aseptically collected composite soil was serially diluted in sterile saline up to 10^{-5} . 0.1 ml of various dilutions were spread on SDA plates containing 100 $\mu\text{g/L}$ chloramphenicol to inhibit bacterial growth and incubated at 29°C for 7days. The dominant isolates were transferred into Czapek's agar medium for 7days and identified according to morphological characteristics and characters of spores (Domsch *et al.*, 1980 and Moubasher, 1993).

Biomass preparation

C. elegans Lender was cultivated in potato dextrose broth prepared from peeled potato tubers and the medium contained (g/L) potato extract (230ml), glucose (20gm) and water 770ml (Gams *et al.*, 1998). After 7 days of incubation at 28°C on rotary shaker at 125 rpm, the fungal growth was harvested by filtration. The harvested biomass was washed with generous amount of deionized water to remove residual growth medium and killed by autoclaving (15lb, 121°C), dried in an oven at 80°C for 24 hr. The dry biomass was powdered to particles by using electric grinder into size ranging from 90 to 500 micrometers (Bai & Abraham, 2001). Then a chemical treatment is underwent which consists in introducing the dried biomass into a solution of sodium hydroxide of 0.01N concentration. The biomass is maintained in suspension by agitation during 30 min at ambient temperature, repeatedly filtered and washed with distilled water, then dried in the drying oven at 80°C until weight remained constant and stored in an air tight container (Krim *et al.*, 2006).

Effect of initial metal concentration and biomass dosage

Biomass concentrations 200, 400 and 600 mg/L were added to 250 ml Erlenmeyer flasks separately. Aliquots (50ml) of 100, 200 and 300 mg/L concentration of cadmium chloride and lead nitrate were added to each flask, and the flasks were left 30 min on a rotary shaker at 120 rpm. The samples were filtered. The concentration of unadsorbed cadmium and lead in the supernatants

were measured by using an atomic adsorption spectrophotometer. Metal uptake (q) was determined from this formula:

$$q = V(C_i - C_{eq}) / m$$

where q (metal uptake, mg/g) is the amount of metal ions adsorbed on the biosorbent, V(mL) the volume of metal containing solution in contact with the biosorbent, C_i (mg/L) the initial concentration of metal ions in the solution C_{eq} (mg/L) the final concentration of metal ions in the solution and m(g) is the dry weight of fungal biomass (Gulnaz *et al.*, 2005).

Effect of initial pH on metal removal

The pH of solution, ranging from 3 to 7 was studied. No buffers, 1N HCl or 1N NaOH were used to adjust the initial pH in case of cadmium and no spontaneous metal precipitation was observed in the prepared solutions after the solution had been in contact with the biosorbent. In the case of lead, pH was adjusted with 0.1N HNO₃ or 0.1 N NH₄OH.

Effect of temperature

The biosorbent (200mg/L) was contacted with heavy metal solutions containing cadmium and lead at an initial concentration of 300 mg/L in an environmental incubator shaker at 20°C, 25°C, 30°C, 35°C and 40°C.

Effect of agitation rate

The effect of the turbulence of the sorbent /sorbate system in cadmium and lead adsorption was monitored at 60, 120, 180 and 200 rpm using a non-agitated system as the control.

Effect of contact time

The biomass (200mg/L) was contacted with cadmium and lead solutions (300 mg/L) for different periods of time. Samples were analyzed every ten minutes and after 24 hr and the adsorption profile was monitored. For all graphical representations, the mean values of the three replicates of the batch experiments were plotted.

Quantification of metal biosorption using Energy Dispersive X-ray (EDAX) microanalysis

Three biomass samples have been prepared for EDAX microanalysis. The pretreated biomass of *C. elegans* Lender was suspended in 100ml of distilled water amended with 300mg/L cadmium or lead, 200mg/L of dried biomass under or the previous optimum conditions. The control biomass was suspended in 100ml of distilled water. Following centrifugation and filtration, each biomass sample was dried in the oven at 60°C until constant weight. Then the dried biomass was holded in special capsule for analysis (Ibrahim *et al.*, 2004).

Heavy metals fractions in the dried dead biomass were examined by the Environmental Scanning Electron Microscope (Model Philips xL 30 ESEM) coupled with energy dispersive X-ray analysis (EDAX). These analyses were carried out in the laboratories of Nuclear Material Authority (NMA), Cairo, Egypt.

Application of cadmium and lead removal capacities by the dried pretreated biomass of C. elegans Lender from different wastewaters

Three wastewater samples were collected from polluted effluents of chemicals factory, dyes factory and battery factory in Tenth of Ramadan City, Industrial region, Sharkia Governorate, Egypt. The initial concentrations of cadmium and lead were determined.

About 100ml of each wastewater sample were collected and 200mg/L of tested dried biomass was added and maintained under obtained optimum conditions. Aliquots of each flask were centrifuged for 15min at 5000rpm and the final concentrations of cadmium and lead were determined.

Elution of metal ions biosorbed by dried pretreated biomass and regeneration

The metal-loaded pretreated biomass after biosorption was conducted with 25ml of elutants deionized water, 15mM HNO₃ and 10mM EDTA for one hour on a rotary shaker (120rpm) to study the removal of biosorbed metal ions. Metal concentrations were determined after separating the biomass from eluting agents by centrifugation for 15min at 5000 rpm, and the final concentrations of cadmium and lead were determined. Use of 15 mM HNO₃ or 10mM EDTA solutions as elutants deposits H⁺ ions on the biomass surface. Excessive amounts of H⁺ ions can reduce the metal biosorption capacity of biomass. Therefore, reuse of the fungal biomass in biosorption after elution of biosorbed metal ions will require H⁺ ions to be removed from the biomass. Washing the biomass with deionized water can remove H⁺ ions until the pH of the wash solution was in the range of 5.0 – 5.4. The biomass regenerated was air dried and its ability to biosorb metal ions was examined (Kapoor *et al.*, 1999).

Results and Discussion

Occurrence of fungi in polluted soil

Soil fungi those able to grow in the presence of heavy metals (50µg/ml of CdCl₂ and pb(NO₃)₂) were isolated and identified. The frequent species were *Aspergillus niger* Van Tieghem, *C. elegans* Lender, *Cochliobolus lunatus* Nelson & Haasis and *Rhizopus arrhizus* Went and Prinsen-Geerligs. *C. elegans* Lender was selected to complete these studies based on its high frequency of occurrence in sampling and it has not been extensively subjected to biosorption studies. It is apparent that certain fungi can exhibited considerable tolerance towards toxic metals and can become dominant microorganisms in some polluted habitats (Gadd, 2007). The heavy metal content of treated and untreated soil is listed in Table 1. The heavy metal contents of treated soil are about two fold or more than the untreated one. The higher amounts of heavy metals in the treated soil are likely due to long-term application of the wastewater containing these heavy metals (Malik & Jaiswal, 2000). The occurrence of various fungi such as *Aspergillus*, *Penicillium*, *Alternaria*, *Geotrichum*, *Fusarium*, *Rhizopus*, *Monilia* and *Trichoderma* in soil polluted with heavy metals (cadmium, nickel, copper, chromium and cobalt) has been also reported by Zafar *et al.* (2007).

TABLE 1. Metal concentration in soil sample of agricultural field receiving long-term application of wastewater.

Metal	Metal concentration ($\mu\text{g/g}$ of soil)	
	Untreated soil	Treated soil
Pb	20.0	45.7
Ni	18.4	32.8
Zn	57.8	100
Cd	1.0	2.2

Because of the important role of cell wall in the metal biosorption by non-viable cells, metal biosorption may be enhanced by heat or chemical sterilization or by grinding. Thus degraded cells would offer a larger available surface area and expose the intracellular components and more surface binding sites due to the destruction of the cell membrane (Errasquin & Vázquez, 2003). Also, Kapoor & Viraraghavan (1995) reported that the alkali treatment (usually with sodium hydroxide) of fungal biomass deacetylates chitin present in the cell wall to form chitosan-glucan complexes with higher affinity for metal ions.

Effect of metal ions concentrations and biomass dosage on metal uptake

Cadmium and lead uptake (mg/g biomass) increased at higher concentrations of cadmium and lead ions and lower biomass dose (Fig. 1). From the figure, the maximum uptake of cadmium (59 mg/g) and lead (71 mg/g) occurred at a biomass of 200 mg/L and initial concentration of cadmium and lead ions 300 mg/L . Ions uptake decreased at 400 and 600 mg/L biomass.

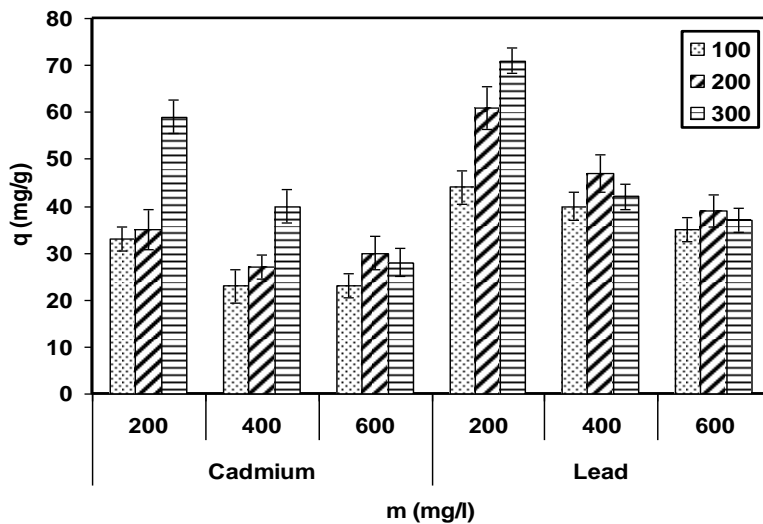


Fig. 1. Effect of initial metal ion concentration (C_i) and biomass dosage (m) on Cd^{2+} and Pb^{2+} ions sorption capacity of dried pretreated *C. elegans*.

Sorption conditions: pH = 5.0 (for Cd^{2+}) and 6.0 (for Pb^{2+}); temperature (T) = 25°C ; contact time = 60min (for Cd^{2+}) and 30min (for Pb^{2+}) and agitation rate = 120 rpm.

The concentration of both the metal ions and the biosorbent is a significant factor to be considered for effective biosorption. The uptake rate of the metal ion will increase along with increasing the initial concentration if the amount of biomass is kept unchanged. Contrary to that, biosorptive capacity of the metal ions is inversely proportional to the initial concentration of the biomass when the initial concentration is kept constant (Wang & Chen, 2006). Further, increment in sorbent dose did not cause significant improvement in adsorption. This seems to be due to the binding of almost all ions to the sorbent and the establishment of equilibrium between ions bound to the sorbent and those remaining unadsorbed in the solution (Bai & Abraham, 2001). Also, Vasudevan *et al.* (2003) found that the process of cadmium biosorption by inactive and deprotonated cells of *Saccharomyces cerevisiae* was dependent on the availability of metal ions in aqueous solution or metal ion concentration. Tsekova & Petrov (2002) reported that at lower biomass concentration the metal/biosorbent ratio was enhanced and thus metal uptake was increased, as long as the biosorbent was not saturated. The decreasing metal uptake at higher biosorbent dosage can be explained by considering a partial cell aggregation that takes place at high biosorbent concentrations causing a decrease in the number of the active sites (Incharoensakdi & Kitjahn, 2002).

Effect of initial pH

The effects of the initial pH on biosorption of cadmium and lead ions are evaluated in the pH range of 3 – 7 (Fig. 2). Investigation of pH values above 7 was not possible since metal precipitation appeared and interfered with accumulation. It can be seen that metal uptake increases with increasing pH from 3 - 5 for cadmium and pH 3 – 6 for lead. Maximum cadmium and lead ions uptake capacities are 58.02 and 48.70 mg/g at pH 5 and 6, respectively.

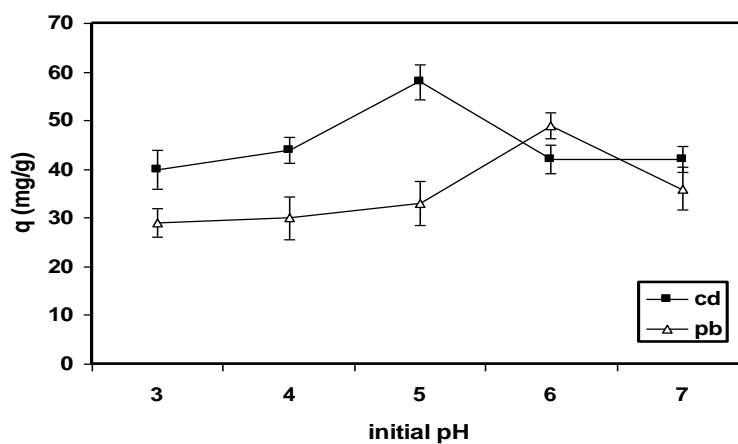


Fig. 2. Effect of initial pH on Cd²⁺ and Pb²⁺ ions sorption capacity of dried pretreated *C. elegans*.

Sorption conditions: C_i = 300mg/l; m = 200mg/l; T = 25°C; contact time = 60min (for Cd²⁺) and 30min (Pb²⁺) and agitation rate = 120 rpm .

For biosorption of heavy metal, pH is one of the most important environmental factors. The pH value of solution strongly influences not only the dissociation site of the biomass surface, but also the solution chemistry of the heavy metals: hydrolysis, complexation by organic and/or inorganic ligands, redox reactions, precipitation, the speciation and the biosorption availability of the heavy metals (Esposito *et al.*, 2002 and Wang, 2002). Teemu *et al.* (2008) reported that an increase in cadmium and lead removal was observed when the pH was raised over 3. This indicated that the increased binding may result from deprotonation of carboxyl groups. They also found that, the dependence of pH indicated that ion exchange was probably at least partly responsible for the observed cadmium and lead binding. At low pH 3, the biosorption capacities for all cadmium and lead are low, because the positively charged hydrogen ions compete with metal ions at sorption sites. As the pH (from 3 to 5) for cadmium and (From 3 to 6) for lead increases, more negatively charged cell surface becomes available thus facilitating greater metal uptake (Ahuja *et al.*, 1999). On the other hand, too high pH value can cause precipitation of metal complexes, which may complicated the sorption process, so it should be avoided during experiments (Wang & Chen, 2006 and Farah *et al.*, 2007).

Effect of temperature

The effect of temperature on cadmium and lead biosorption is represented in Fig. 3. Over the range (20 – 40°C), the temperature- related effects do not appear to be particularly pronounced. Maximum biosorption for cadmium and lead occurred at 25°C.

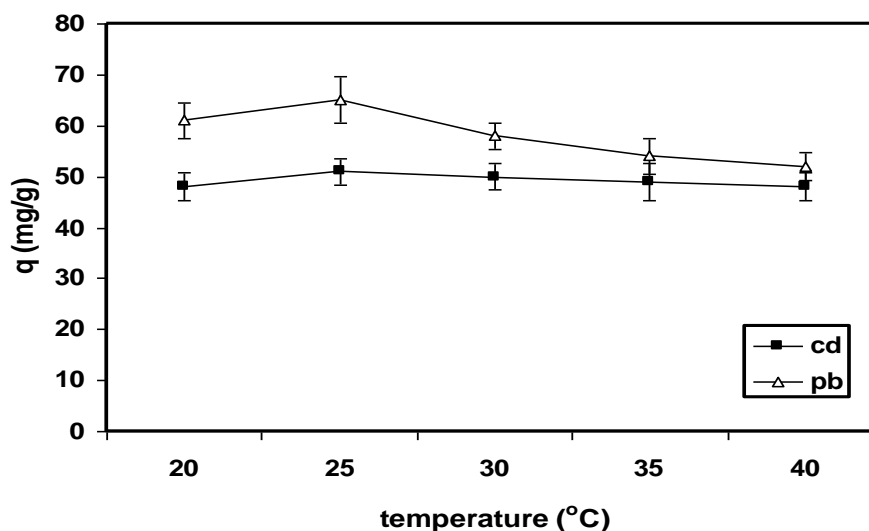


Fig. 3. Effect of temperature on Cd^{2+} and Pb^{2+} ions sorption capacity of dried pretreated *C. elegans*.

Sorption conditions: $C_i = 300\text{mg/l}$; $m = 200\text{mg/l}$; pH = 5.0 (for Cd^{2+}) and 6.0 (for Pb^{2+}); contact time = 60min (for Cd^{2+}) and 30min (Pb^{2+}) and agitation rate = 120 rpm

The decrease in biosorption capacity at higher temperature between 25 and 40°C may be due to the damage of active binding sites of the cell surface available for metal biosorption (Özer & Özer, 2003). On the other hand, higher temperature usually enhance sorption due to the increased surface activity, binding sites on the relevant cell mass and kinetic energy of the solute (Vijayaraghavan & Yun, 2007).

Effect of contact time

The contact time is of great importance in adsorption for the assessment of the suitability of these fungal preparations to serve as biosorbents in a continuous flow system. Fig. 4 shows the effects of contact time for the sorption of Cd^{2+} and Pb^{2+} ions by dried pretreated biomass of *C. elegans*. Cadmium and lead uptake increased rapidly with time and reached the maximum after 60min and 30min, respectively. The rapid Cd^{2+} and Pb^{2+} uptake proves that the removal of them by *C. elegans* is due to adsorption or bioadsorption which typically occurs rapidly (Nabil *et al.*, 1997).

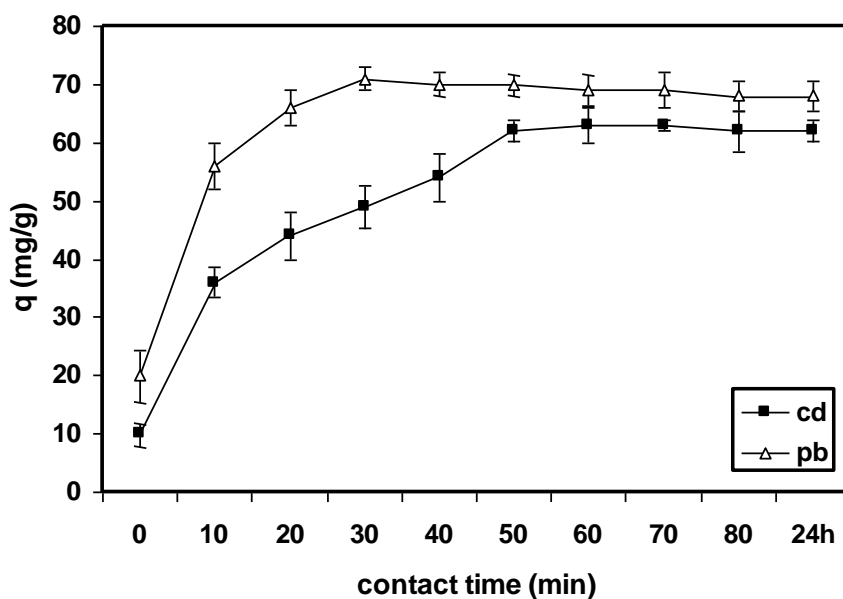


Fig. 4. Effect of contact time on Cd^{2+} and Pb^{2+} ions sorption capacity of dried pretreated *C. elegans*.

Sorption conditions: $C_i = 300\text{mg/l}$; $m = 200\text{mg/l}$; pH = 5.0 (for Cd^{2+}) and 6.0 (for Pb^{2+}); $T = 25^\circ\text{C}$ and agitation rate = 120 rpm

Effect of agitation rate

The effect of the turbulence of the sorbent/sorbate system in cadmium and lead adsorption was monitored at low, medium and high speeds of agitation using a non-agitated system as the control (0 - 200 rpm). All agitation speeds were found to have a positive effect over the non-agitated system as exemplified in Fig.5. Optimal

values of adsorption capacity are obtained at the stirring speed of 120 rpm for cadmium and lead. This is because agitation at this speed may facilitates proper contact between the metal ions in solution and the biomass binding sites and thereby promotes effective transfer of sorbate ions to the sorbent sites. The moderate speed gives the best homogeneity for the mixture suspension (Bai & Abraham, 2001). But, high stirring speed, vortex phenomenon occurs and the suspension is no longer homogenous which makes the adsorption of cadmium and lead difficult (Yun-Guo *et al.*, 2006).

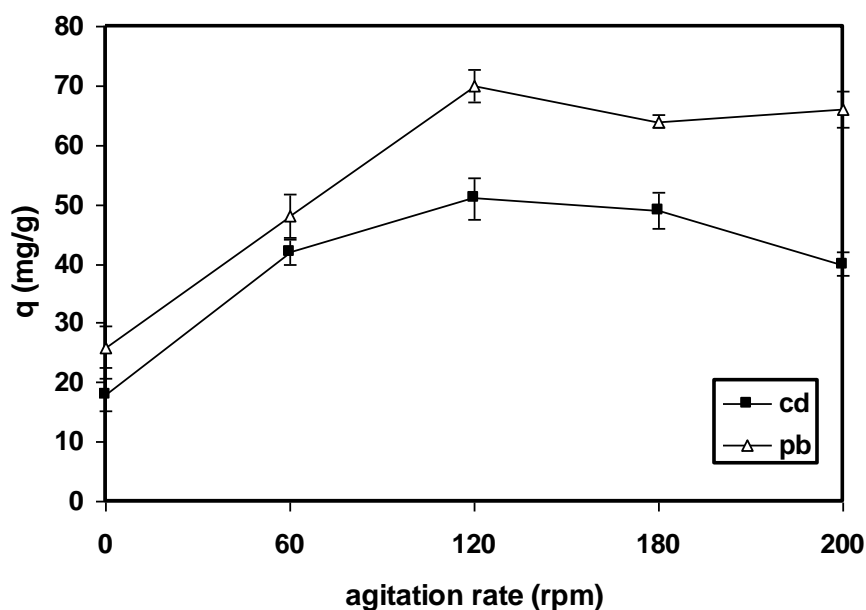


Fig.5. Effect of agitation rate on Cd^{2+} and Pb^{2+} ions sorption capacity of dried pretreated *C. elegans*.

Sorption conditions: $C_i = 300\text{mg/l}$; $m = 200\text{mg/l}$; $\text{pH} = 5.0$ (for Cd^{2+}) and 6.0 (for Pb^{2+}); $T = 25^\circ\text{C}$ and contact time = 60min (for Cd^{2+}) and 30min (for Pb^{2+})

Quantification of metal biosorption

Figures 6-8 represent EDAX spectra and concentrations of semiquantified results of native, cadmium- exposed and lead-exposed cells. The peaks of Si, P, S, Ca, Ni and Cu were detected as elements present on the surface of native cells (Fig. 6). The atomic percent of P and S increased with Cd^{2+} and Pb^{2+} uptake, respectively (Fig. 7 and 8). This coprecipitation of Cd^{2+} with P and Pb^{2+} with S suggest that phosphate may be sequestering Cd in the form of Cd-phosphate complexes and Pb in the form of Pb-sulphate complexes. Aloysius *et al.* (1999) reported that the mechanism of sequestration of cadmium ions on the surface of *Rhizopus oligosporus* was proved to be a bioadsorption phenomenon. They also found that the conspicuous phosphorus peak in the EDAX spectrum indicated that the metal may be deposited in the form of

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cadmium phosphate. Ariff *et al.* (1999) studied the mechanism of lead biosorption by powderized *R. oligosporus* using transmission electron microscope and energy dispersive X-ray analysis. They confirmed that during sorption most of the lead was adsorbed on the surface of cell.

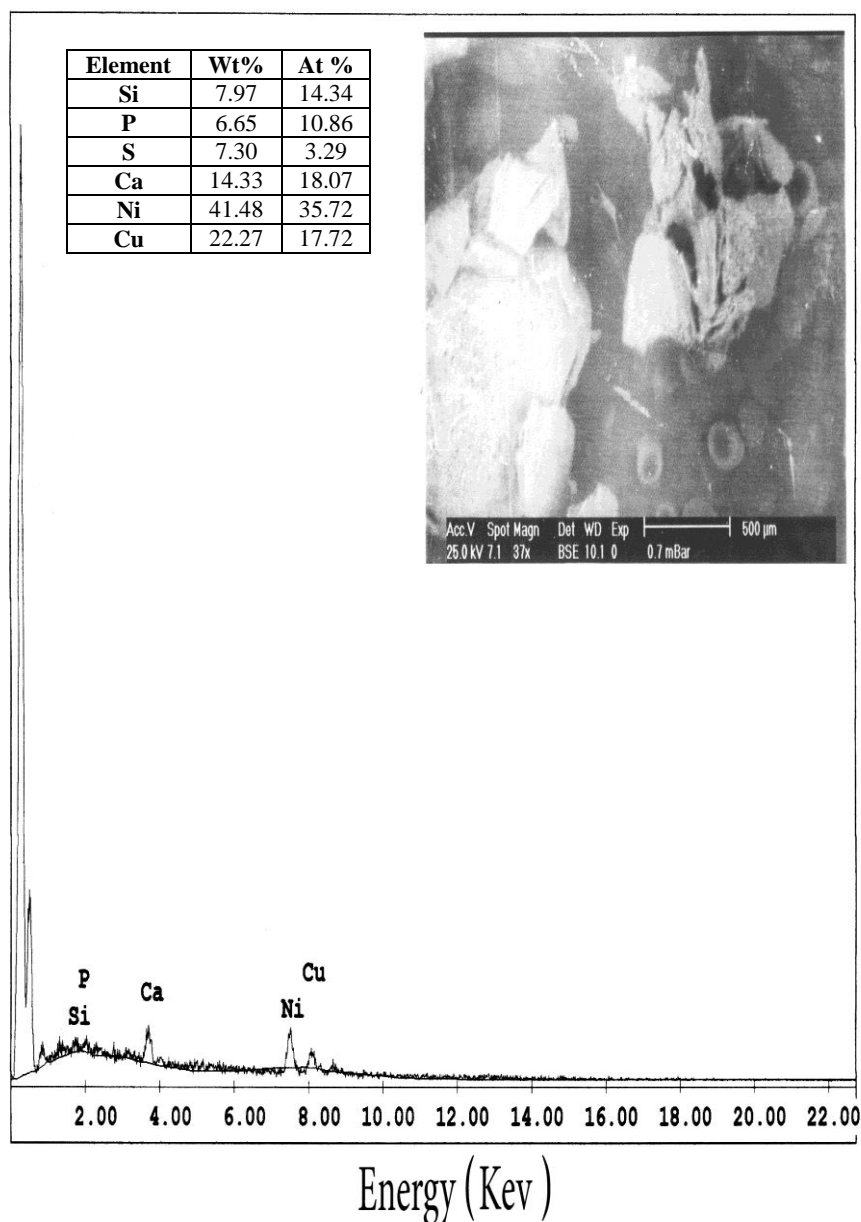


Fig.6. EDAX spectroscopy depicting the presence of elements on native dried biomass of *C. elegans*.

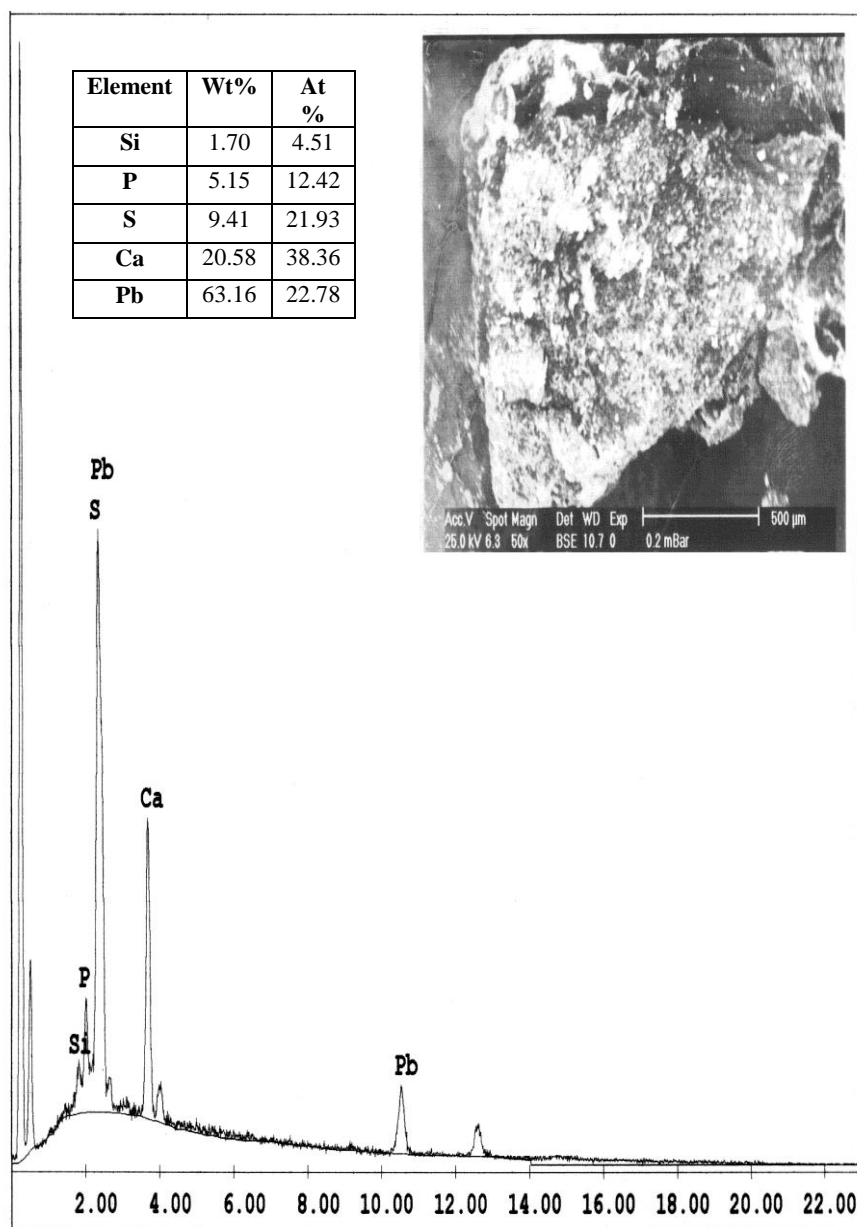


Fig. 7. EDAX spectroscopy depicting the lead biosorption on the tested dried biomass of *C. elegans*.

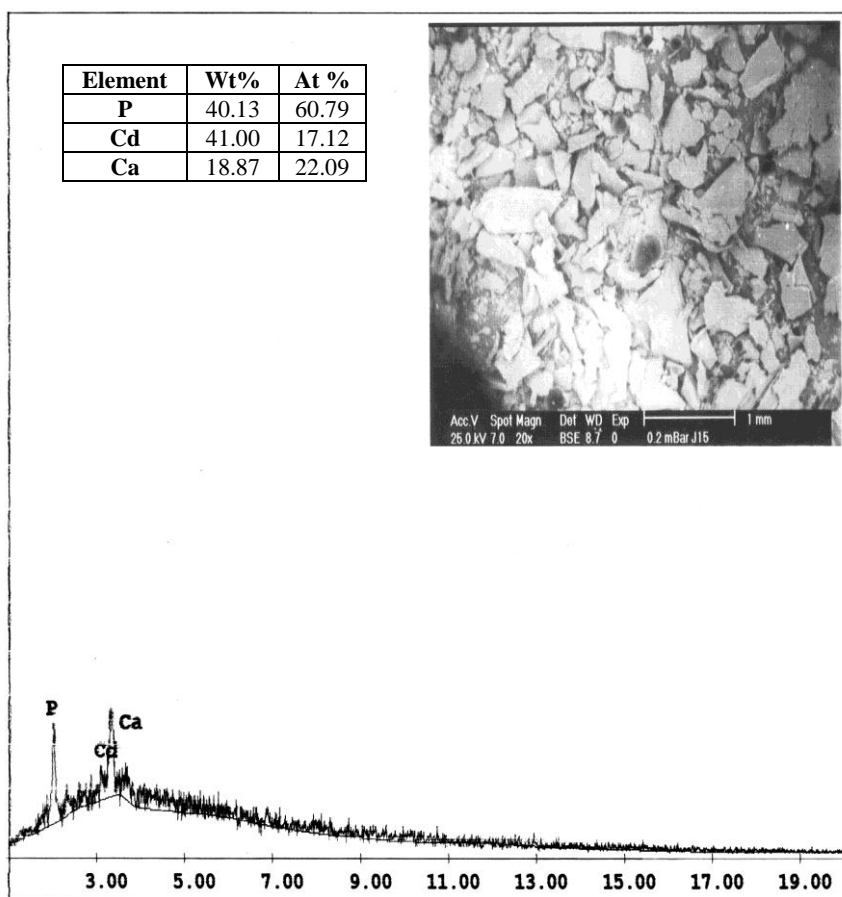


Fig. 8. EDAX spectroscopy depicting the cadmium biosorption on the tested dried biomass of *C. elegans*.

El-Sayed (2009) using the EDAX analysis indicated higher accumulation of cadmium on *Pseudomonas aeruginosa* surface more than zinc and copper.

Elution of metal ions biosorbed by dried pretreated biomass and regeneration

The pretreated biomass showed stronger affinity for removal of Cd^{+2} and Pb^{+2} from wastewaters of dyes factory and battery factory more than that of chemicals factory. *C. elegans* Lender biomass was more efficient in the removal of lead especially from battery factory and dyes factory than cadmium from all tested wastewaters. The adsorption is easy to understand when it refers to a single metal situation; however in a multi-ion situation, which is generally encountered in effluent, the assessment becomes complicated. The biosorbed metal ions were eluted from pretreated biomass using three elutants. Table 2 compares the

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removal efficiency of various chemicals in eluting biosorbed metal ions. Deionized water was able to elute biosorbed metal ions only to a limited extent, indicating the strong affinity that biomass possesses towards the metal ions. 15mM HNO₃ solution was able to effectively elute the biosorbed cadmium from all used polluted samples. Meanwhile, 10mM EDTA solution was able to effectively elute the biosorbed lead from all used polluted wastewaters.

TABLE 2. The elution of biosorbed metals from wastewater of chemicals factory, dyes factory and battery factory by various chemical reagents .

Chemical	Chemicals factory		Dyes factory		Battery factory	
	% recovery of biosorbed Cd	% recovery of biosorbed Pb	% recovery of biosorbed Cd	% recovery of biosorbed Pb	% recovery of biosorbed Cd	% recovery of biosorbed Pb
Deionized water	19	12	15	7	28	11
10m M EDTA	35	68	38	98	46	60
15m M HNO ₃	88	48	55	70	61	48

The biomass was reused to study the changes in metal biosorption with subsequent usage (Fig. 9). Biomass lost a little portion of its cadmium and lead biosorption capacity for the chemicals factory, on contrary, biomass retain its biosorption capacity for both metal ions from wastewater of dyes factory and battery factory.

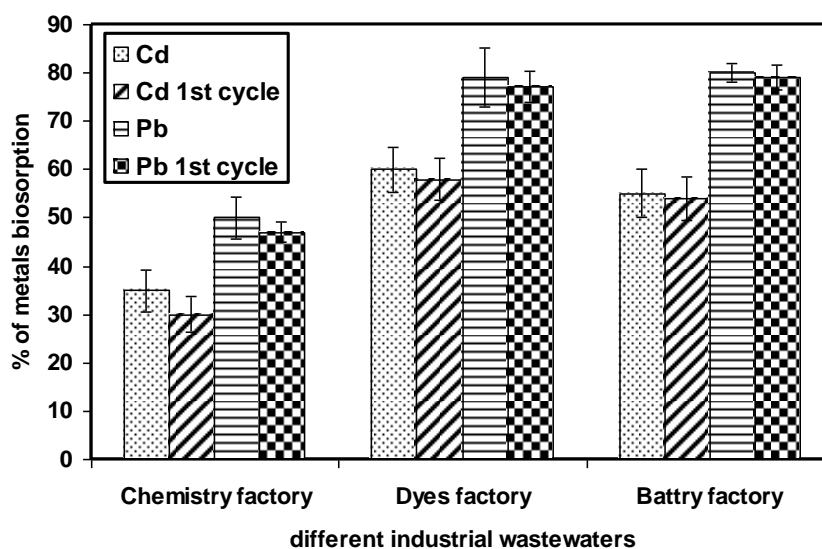


Fig. 9. Sorption of Cd²⁺ and Pb²⁺ ions from different wastewaters by dried pretreated *C. elegans*

Desorption of loaded biomass enables reuse of the biomass and recovery and/or containment of sorbed materials, it is desirable that the desorbing agents does not significantly damage or degrade the biomass (Gadd, 2008). Yan & Viraraghavan (2003) reported that metal ions adsorbed by the dead biomass of *Mucor rouxii* could be eluted effectively with HNO₃, while distilled water demonstrated negligible metal elution capability. The degree of reduction in removal depended on the biomass and desorbent used. A variation was reported from 1% to 63% for dilute acid, and from 6.5% to 30% for EDTA (Senthilkumar *et al.*, 2007). This was in agreement with the explanation by Teemu *et al.* (2008) who mentioned that the reduction in metal removal may also be related to concomitant removal of some surface components by acids and EDTA.

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الامتصاص الحيوى لأيونات الكاديوم والرصاص بواسطة الكتلة الحيوية لـ *Cunninghamella elagans*

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تم عزل فطره *Cunninghamella elagans* من تربة زراعية معالجة بمياه صرف صناعى تم اختيارها على أساس انتشارها من أجل تقييم مقدرتها على امتصاص أيونات الكاديوم والرصاص . تم معالجة الكتلة الحيوية الميتة معاملة قلوية . تأثيرات تركيز الكتلة الحيوية ، التركيز الأولى للعنصر ، تركيز أيون هيدروجين ، الوقت ، درجة الحرارة ومعدل الأهتزاز تم دراستهم . أقصى معدل امتصاص لأيونات الكاديوم والرصاص كان ٥٩ مللى / جرام و ٧١ مللى جرام / جرام عندما كان التركيز الأولى ٣٠٠ مللى جرام / لتر وتركيز الكتلة الحيوية ٢٠٠ مللى جرام / لتر . درجة التركيز أيون الهيدروجين المثلى للكاديوم والرصاص كانت ٦.٥ . أفضل درجة حرارة كانت ٢٥ ° لأيونات الكاديوم والرصاص . أقصى امتصاص للكاديوم كان بعد ٦٠ دقيقة بينما الرصاص بعد ٣٠ دقيقة . أفضل معدل اهتزاز كان ١٢٠ لفة / دقيقة لإزالة أيونات العنصرين . الميكروسكوب الإلكتروني الماسح المتصل بأشعة أكس أوضح أن الكاديوم والرصاص تم استبدالهم مع عناصر كانت موجودة على سطح الخلايا الأصلية لفطره *Cunninghamella elagans* ، وهذا يفسر أن التبادل الأيونى واحد من اللآليات السائدة . الكتلة الحيوية ذات المعاملة القلوية تم اختبارها لإزالة أيونات الكاديوم والرصاص من ثلاث عينات من مياه الصرف . أيونات الكاديوم و الرصاص تم إزالتهم بكفاءة باستخدام ١٥ مللى مولار لحمض النيترىك و ١٠ مللى مولار إتنا على التوالى.